Photo-Lithography

PHOTO-LITHOGRAPHY

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THE AUTHOR'S PREFACE.

Photo-lithography, with its many branches and its extended application, when used direct and also as handmaid for the lithographer and printer from stone, is, with the exception of phototypy and autotypy, indeed that process for the preparation of letterpress plates which has done the most towards making photography useful for the graphic arts, in the artistic sense as well as from the practical point of view. And in the near future it will be a great acquisition when it is once generally recognized that colour plates can be prepared by photographic means without any considerable amount of manual or artistic help. It is the more to be wondered at that photo-lithography has not yet found that extension and general use which it in so high a degree deserves.

I have written this book, impressed with the urgency of stimulating the propagation of this useful process. In writing I have been careful to avoid all those details which are for the practical worker of minor interest—the description of the historical evolution, etc., so instructive as these must certainly be —so that I have abstained from many complicated and unintelligible formulæ. I leave this willingly to a more ready writer. Starting rather from the standpoint of speaking as a practical worker to practical men, I have recorded all the experience which I have gained in the course of many years.

Should it occur to me in the future that it was my task to have treated all photo-lithographic processes, with all their ramifications, in the most complete manner, I have still the consciousness of having described as completely as possible the practical processes, and think that I have thus been useful to many workers,

and I dare say with absolute certainty that only tested and tried formulæ have been noticed in this book.

With the earnest wish that this book may be received with a fraction of the goodwill with which I have worked at the writing of the same, I present it to the technical world.

GEORG FRITZ.

Vienna.

On receiving this work for review I was greatly struck with the thoroughly practical manner in which it was written, and thought than an English translation might be acceptable to the large and ever increasing class of photo-mechanical workers who might not otherwise have the opportunity of reading it in the original. I have kept to the author's text as close as is consistent with the idiomatic construction of German.

I am indebted to Messrs. Hazell, Watson and Viney for permission to undertake the task of translating the work for another firm of publishers, and I hope the translation may prove as acceptable and useful to the readers as it has been pleasurable to me to do it.

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INTRODUCTION.

1.—*The theory of printing from stone.* He who would study or practise photo-lithography must first become acquainted with the fundamental principles on which lithography rests. I find it therefore necessary to first give in concise form a small treatise on the theory of this process as well as on the most important materials which are necessary in the practice of the same.

The theoretical principle of lithography is purely chemical, and is based principally on the repulsion of water and other substances by fatty bodies, and the alteration of these greasy bodies by acids. As the support for this chemical opposition a stone or zinc plate is used, which are sufficiently porous to allow grease, water, acid, and certain resinous solutions to penetrate to a certain degree.

The fatty substances which are transferred to the stone by writing, drawing, or transfer, are autographic ink, lithographic ink, and chalk, the so-called transfer and photo-lithographic colours. There are also other substances, which are used especially in photo-lithography, which do not evidently penetrate the stone and which cannot be considered as greasy substances, but which, as we shall see later on, have exactly the same action.

The above-mentioned fatty substances actually penetrate the porous stone and make it in places suitable to take more printing ink. By the so-called etching—dilute nitric acid mixed with gum water—two effects are produced. On the one hand the fatty bodies are altered in chemical composition, being decomposed into the fatty acids which combine intimately with the material of the stone—calcium carbonate. On the other hand, the surface of the stone not covered with the fatty substances is chemically changed, since the carbonate of lime is converted into nitrate, which has now the property of keeping moderately damp when moistened with water, and thus repelling grease. If such a transfer of greasy bodies on to the stone is allowed to act for some hours, and the fatty substances are removed with turpentine, it will be seen that these places have a lighter colour than the other parts of the surface of the stone, and if the stone be rolled up with a leather roller, charged with a greasy ink, after the stone

has been damped, only these places will take the greasy ink. By means of a litho steam or hand press prints can then be prepared from this.

It is frequently necessary to make corrections or additions to the drawing on the stone; if the stone has been already etched some means must be used *which will remove the action of the etching*, or else the stone will not take the greasy matter, or at least not so readily as is desirable. Very weak acetic acid, about 1-2 per cent., will do this. If the stone is flowed over with this dilute acetic acid or dilute table vinegar, the action of the stronger nitric acid and the gum is stopped, and the surface of the stone will again take fatty matter.

Before the penetration of the grease the stone is prepared by polishing with a concentrated solution of oxalic acid. Oxalic acid poured on to the stone would exert an etching action, but make the stone to a certain degree capable of taking the ink. If this liquid is rubbed on the stone with a cloth or linen pad with moderate pressure, the stone receives a high polish—especially the hard kinds—and in this condition the stone takes the ink well, like any flat object, but will not retain it. If a transfer is made on to such a stone, and the same etched, the image will completely disappear the first time the roller passes over it. This polish can be removed with 1 or 2 per cent. acetic acid, and the stone then has its primitive qualities. This method is used to reverse the image, which will be described later on.

2.—*Litho stone* is dense limestone of the mountain limestone group, and is found in the Tertiary deposits at a depth of two to three metres. Its constituents are lime, clay, and silicious earths, combined with carbonic acid, but lime is in the preponderance; it only contains a very small proportion of silica. In the stronger acids litho stone dissolves completely. The varieties of very fine stalactitic chalk of tolerable hardness, with flat shell-like fracture, without rust spots, glassy crystals or impurities, and those with very even grain, are the most useful for photo-lithography. Marble, which consists of pure chalk, cannot be used for lithography because, on account of its greater density, the greasy matter cannot penetrate so deeply, and therefore such stones would give only a few pulls.

The commercial litho stones are of different colours, from whitish yellow to greenish shining grey. The latter has a finer and more even grain, and is considerably harder than the other kind. These two kinds are briefly designated in the trade as "yellow" and "blue," and the brighter kinds are, as a rule, softer and cheaper than the darker.

The faults which the stones sometimes show differ considerably, and these produce certain inconveniences in continuous work. Many stones have dark and light spots, and as these spots have, as a rule, different densities, the etching solution cannot exert the

same action over the whole of the stone, and consequently in fine drawings, autotypes, etc., there are formed bright and dark spots. This also occurs with calcareous, speckled, and marbly stones. The very bright stones have less density, and therefore suck up the damping solution very quickly, and begin with repeated printing to become tinted. Stones with calcareous, rusty or other veins split easily, especially in the large sizes. Lime spots or lime veins, which are easily recognized by their brighter colour, take in graining a very unequal grain. The drawing is darker on these places, since the grain is greater according to the softness of the stone. Such stones are unsuitable for those photo-lithographic processes in which graining is used, such as the processes of Orell and Füssli and Bartös. The so-called glass veins and glass spots are crystallizations consisting of silicon, and are harder than the other parts of the stone. On these places the fatty inks do not penetrate deep enough, and the drawing does not adhere well, and can be easily removed by the rollers.

The hard stones receive a much finer surface than the soft when polished with pumice stone; they also reproduce every point, line, and detail of the drawing much more delicately, finer, and sharper; and, lastly, they have the advantage that they etch much more evenly, and re-etching is easy if moderate care be taken.

For the finer photo-lithographic work, if quality and continuous working is desired, only the good "blue" stones should be used; for cheaper line drawings "yellow" stones free from faults may be used.

3.—*The zinc plates* are now coming into pretty general use instead of stones, especially in large establishments. Although their treatment before and during printing is essentially different to that of the stones, yet so far as regards this method of printing they come very nearly equal to stones. At first smooth polished zinc plates were used, but in consequence of some difficulty in using them, and the great care necessary in choosing them, they have been almost replaced by the prepared or oxidized plates.

Zincographic processes differ essentially in the preparation of the plates. In the one, the plate is given a coating which has a similar composition to a litho stone; in the other, the plate is roughened and given a fine grain by a mechanical method, such as the sandblast, in order that it may be then oxidized by a chemical process, with acids or alkalies. All these processes are more or less advantageous. The zinc plates cost about one-tenth to one-twentieth of the cost of the stones, and this may well be sufficient grounds for the proprietors of large establishments being interested in zinc plates, as the stones are rather costly.

Excellent zinc plates, coated with a film or merely oxidized, can be procured commercially in Germany and Austria. For those

who wish to prepare their own plates the following tested formulæ are given :—

A zinc plate from 1 to 1·5 mm. thick is roughened by means of the sandblast till it has a fine, even grain and appears smooth, but clear. The following solution is prepared :—

Concentrated solution of alum ...	20 parts
Phosphoric acid	2 „
Water	20 „

or

Alum solution...	10 parts
Gallic acid	15 „
Nitric acid	2 „
Water	30 „

The roughened plate is first flowed over with water, and immediately afterwards, with one of the above solutions, in the same way as a plate, is covered with a developer. The plate is oxidized by this, and there is formed on the surface a white precipitate. It is then washed thoroughly under a rose tap and dried, and the plate may be either coated with a light sensitive substance for printing or a transfer be made on to it.

After the development or the transfer, the plate is gummed and then etched with an etching solution consisting of—

Gallic acid	10 parts
Phosphoric acid	2 „
Gum solution	10 „
Water	30 „

this being allowed to act for 30 or 40 seconds.

For repeated printing one to two per cent. of gallic acid is added to the damping water.

If the plate has been correctly treated the print or the photo-litho transfer will furnish thousands of good impressions, just like a stone. Further details as to the printing on the zinc plates, or the transfer of the chromated gelatine prints on to the same, will be found in Chapter IV.

4.—*The greasy drawing materials* which are necessary for lithography are litho tusch, autographic ink, and fatty chalk.

The two first are used in the liquid state, the chalk, however, in solid form. The ink can be obtained in a liquid form and the two others in solid state. All three materials consist principally of soap, tallow, wax, resin, and soot. Soap and tallow give the necessary grease, wax and resin give hardness and consistency, and soot the colour. The proportion of grease in the drawing materials must be so great that even the finest lines or points of a drawing can be well transferred to the stone, so that they may not be attacked by the proper etching solution, and do not break away from the stone by continuous printing. As much black as possible in the drawing materials is pleasant for the draughtsman, but is not actually necessary for this particular purpose.

The tusch must dissolve well in distilled water and flow fine and clean from the pen. It should be tolerably brittle, and the fractured surfaces should be shiny. The photo-lithographer will frequently require the lithographic tusch for additions or for corrections. The best is the so-called Lemercier's tusch, which is used in nearly all works. It consists of—

Yellow wax	2 parts
Mutton tallow	2 „
Marseilles soap	6 „
Shellac	3 „
Lamp black	1-2 „

These ingredients should be melted together by boiling.

The autographic ink is, as a rule, used for drawing or writing on paper, and the result is then transferred to the stone. Instead of this, any litho tusch can be used, but for some work the autographic ink is more advantageous. This ink must be thin, run easily, but not patchily, from the pen, and must keep for a long time equal in quality and action. It is very advantageous that specially-prepared paper is not required, since this always makes the work more difficult; firm, hard writing-paper is quite good enough for this work. The commercial inks generally possess these good qualities, and if much is not required one will hardly care to prepare it oneself. A good successful autographic ink which draws in brown may be obtained from the following formula:—

Marseilles soap	10 parts
Tallow	10 „
Shellac...	12 „
Yellow wax	12 „
Mastic	5 „
Asphalt	4 „
Vine soot	3 „
Distilled water	125 „

Originals prepared with this ink transfer as well immediately as after several months, and ordinary well-sized writing paper can be used for drawing or writing on.

Lithographic chalk is only prepared in the solid form for drawing on paper direct or on stone. According to the nature of the work, it is harder or softer, fatter or leaner. The hard kinds, which are also usually leaner, contain more resin and less fat; the soft, on the contrary, more grease.

Fatty chalk is composed of —

Wax	30 parts.
Marseilles soap	24 „
Tallow	4 „
Shellac	1 part.
Lampblack	6 parts.

Lean chalk is composed of —

Wax	12 parts.
Marseilles soap	8 ,,
Tallow...	2 ,,
Shellac	10 ,,
Lampblack	4 ,,

For lithographic work a greasy ink is required in contra-distinction to ordinary printing ink, which consists of linseed oil and lampblack, which would be called "lean." For inking-up a photo-lithographic chromated gelatine print such an ink cannot be used. In order to obtain a good result in transferring, this ink must contain grease, soap, and resin.

Any good transfer ink can be used for a developing ink, as this is applied with a roller. It usually consists of equal parts of tallow, wax, soap, some resin, and as much litho ink as all the other ingredients put together.

That prepared by C. Kampmann, Technical Instructor in the K.K. Lehr-und Versuchsanstalt at Vienna, contains, besides the above-named ingredients, asphalt and gum elemi, and works well in practice.

Thin developing inks, which are distributed with a broad brush or a pad, can be prepared by diluting good transfer ink with equal quantities of wax, benzine, and turpentine.

A good developing ink must have the following properties: When spread upon the print must give a clean, sharp, sufficiently dense impression, which can be easily transferred to the plate or stone; on the other hand, the drawing ought not to spread. The transfer should possess such resistance that, without rolling up, it should resist a slight etching.

5.—*The behaviour of asphalt on stone or zinc.* When a stone or plate is coated with asphalt solution and exposed under a negative, and then washed with turpentine, the exposed parts remain insoluble, and in this way photo-lithographs can be prepared. The asphalt here takes the place of the fatty ink, and is, after printing, so firm and hard that without any rolling or inking up it can be etched with a weak, gummy, etching solution, which gives a cleaner, sharper drawing than the other processes. The asphalt and other light sensitive resins not only intimately combine with the stone or plate, but chemically alter the surface of the stone, and possibly in a more advantageous way than the greasy inks. When a properly-exposed drawing on stone is, immediately after printing and development, treated for a long time with rectified or Neustadt turpentine, it is completely removed from the stone, and it will be found that the drawing appears of a somewhat lighter colour than the rest of the surface of the stone. If this is now inked up with a roller, these places take up the ink *without having previously come into contact with grease.* Numerous experiments which I have made on various lines go to show that the

chemical theory of lithography has found an important enlargement with the use of asphalt.

The following are principal conclusions to be drawn from my experiments :—

(*a.*) The exposed asphalt, whether this exposure is made by printing or whether a drawing is first made and then exposed to the light, adheres more firmly to the stone or zinc plate than if it was not exposed. An asphalt drawing prepared in the dark and inked up does not adhere to the stone, and this may be explained in that the grease cannot act through the asphalt film. Insensitive asphalt behaves in the same way. With correct exposure under a clear negative of about 20 degrees Vogel, and subsequent development and auxiliary exposure for about half to one hour, the drawing adheres firmly to the stone. If the image is to be washed off, the turpentine must act for five to ten minutes on the film, till the exposed asphalt has dissolved. If, after washing off, it is inked up, all the places take the ink well, and the image appears clear and plain. The image can only be destroyed by strong acids or alkalies, which actually dissolve the stone itself.

From this it is clear that the prints neither require inking up nor strengthening in any other way, and my experiments have proved that in all cases the prints are, by this treatment, clogged up, and neither gain as regards a longer run nor in withstanding etching.

(*b.*) Solution of asphalt, to which oil has not been added, behaves as described above ; if, however, oil is added to it, it acts still better as regards the keeping of the drawing, and the prints need no subsequent exposure. Too large an addition of oil has the disadvantage that, in developing with turpentine, the asphalt dissolves too quickly. The images wash off and one hardly has time to examine. The exposed asphalt, to which oil has been added, also dissolves very readily. For the preparation of colour plates this point is of some importance.

6.—The etching and preparing solutions are those solutions which make the stone suitable or unsuitable for taking the grease or water. Generally these are acids and gum arabic, either used alone or together.

Of the acids the most important is *nitric acid*, the purpose of which is to convert the surface of the stone into a nitrate, so that the grease cannot penetrate. This acid acts even when diluted very energetically on the stone, and produces a fine grain.

Hydrochloric acid exerts a less energetic action; it leaves the stone smoother and does not attack it so evenly as nitric acid, but has the same result finally.

Sulphuric acid ought not to be used for etching stone. It forms calcium sulphate on the surface of the stone, and this separates from the stone in printing and spoils the pulls.

Phosphoric acid may be used for etching as well as for preparing the stone; it exerts a very faint etching action and is seldom used for this purpose, but principally for making corrections.

Acetic acid plays a very important part in lithography. It possesses the property, even in very dilute condition, of stopping the action of the gum and oxalic acid, and, indeed, even that of the stronger nitric, sulphuric, and hydrochloric acids. It finds, therefore, considerable use in negative printing, in making corrections, etc. It converts the stone into its original condition and makes it suitable again for taking ink.

Citric acid fulfils the same purpose, but is, however, much higher in price.

Oxalic acid is not used for etching, but only for preparation of the stone. By rubbing the stone with a solution of oxalic acid with a pad of cloth it takes a mirror-like surface or polish, into which the fatty ink cannot penetrate. It is used for preparing the stone for lithogravure, negative drawing, and negative transfer, etc.

Tincture of galls, or instead of this, what is simpler, gallic acid, is used in lithography. It contains plenty of tannin, and is one of the most efficacious means of preventing the combination of the stone or zinc plate with fatty substances.

Gum arabic or some other vegetable gum is indispensable for litho and zincography. A 10 per cent. solution of gum is generally used. It penetrates all the pores of the stone and the plate, and gives the same a thin but very firm film, and prevents the ink taking on these places. If it has become slightly acid it acts as a weak etcher, and as an addition to nitric acid it makes the same of thicker consistence and more easily distributable. The action of gum can be removed with acetic or citric acid; with water alone this cannot be perfectly effected.

7.—*Etching the stone.* There are two principal etchings, the *simple ordinary or first etching*, which obviously has the purpose of giving the drawing the necessary stability and protecting the blank places from taking ink, and *the deep or sharp etching* gives for combination printing a still greater lasting power, and for large runs keeps the drawing clean and sharp.

The ordinary etching chiefly causes the fatty substances to assume a new chemical condition, since in combination with the stone they form insoluble fatty salts of lime, which represent the printing surfaces. It has, however, also the property of cleaning the blank stone surfaces from any adherent grease, and makes the blank parts of the stone incapable of taking ink; also it makes the drawing clearer and more precise.

The strength of the first etching may differ, according to the following circumstances:—

(*a.*) The stone; for hard stones stand a stronger, and soft stones a weaker etching.

(*b.*) The printing image ; fine drawings must at first be etched with a weaker solution ; coarser drawings, on the other hand, will stand a fairly strong etcher.

(*c.*) The material with which the print or drawing has been prepared ; very fatty developing inks and asphalt stand well even with strong etching, whereas with lean or hard inks only a weak etching should be used.

An etching solution which is at the limit of strength, but still suitable for a hard stone or a very coarse drawing, would irretrievably ruin a very fine drawing on a soft stone.

Commercial acids differ considerably in strength, and it is, therefore, better to use a hydrometer than a measure It is also always more satisfactory not to use the acid by itself, but in conjunction with gum. A solution of gum of eight to ten degrees strength is diluted with nitric acid till it measures 10 to 12 degrees on the hydrometer. This solution may be safely used for every case, and it is only necessary to allow it to act longer for coarser drawings ; it should be evenly distributed over the surface of the stone with a clean soft pad. In very hot weather it acts more energetically, and then it should be used weaker for fine work. In any case it is advisable to let the stone or plate stand for some hours before etching, so that the ink may thoroughly combine. The etching of zinc plates will be more fully described later on; in other respects the treatment is the same as for stone.

8.—*Deep-etching process.* The idea of this is chiefly to increase the printing form and to make the stone more resistant in printing. In working this the principal thing is to sufficiently protect the drawing from the action of the strong acid. This is generally done by dusting with resin, which has a low melting point.

There are two deep-etching processes which are chiefly used, one in which the resin is melted with a spirit flame, the other in which the same thing is done by ether vapour.

The procedure in each case is extremely simple. In the so-called burnt-etching process, which has been perfected by Eberle, of Vienna, the already etched stone ready for printing is rolled up with a very stiff printing ink, not transfer ink, and then the drawing dusted with the finest powdered resin. The stone is then gone over with a cotton-wool pad and plenty of talc or French chalk, and then well dusted off with a broad camel's hair brush in order to remove all traces of resin from the blank stone. To melt the resin a spirit lamp with a side flame is used. The flame is passed over the drawing, and ought only to be allowed to act sufficiently long to make the resin combine with the ink, which can be recognized by the drawing looking shiny. If it has been melted too long the sharpness of the drawing is damaged. After this the etching may be at once proceeded with, and this is effected with a solution of gum to which 8 to 10 per cent. by measure of 44 per cent. nitric acid has been added. For fine drawings 4 to

6 per cent. of acid should be used. In using this a fairly strong effervescence takes place, which should not frighten anyone.

In the ether or cold-melting process exactly the same procedure takes place, only that instead of melting with an open flame this is effected by ether vapour.

For this work a wooden stick of about 2 mm. thick is laid on two edges of the stone. On another ruler, which should be large enough to cover the whole of the stone, and which should be covered with flannel or stout cloth, ether is poured; this ruler is laid on the others, so that it forms a right angle with them, and is slowly drawn over the surface of the stone. The ether vapour falls on to the surface of the stone and dissolves the resin which thus forms the protective film for the deep etching, which is done precisely as described above.

Another melting process recommended by Scamoni consists in pouring alcohol on the stone and then setting fire to it.

9.—*Differentiation of the printing processes.* Technically we differentiate the principal printing methods into three, according to the method of production. *The first and oldest* is the typographic or letterpress printing, which is founded on the principle that every line or every point which ought to print must stand up on the plate, and all those places which must appear white in the print must be sunken in. The artistic effect is obtained by tones which are formed of individual lines or points, which are closer together or further apart, or else print finer or deeper. In printing a forme or plate, etc., it must be "made ready," that is to say, the pressure in printing must be so arranged for each part of the picture that on the lighter places or finer places less pressure must be exerted, whilst on the deeper tones more pressure should fall, according to their gradation. This balancing, which is technically termed "making ready," is effected by cutting out the delicate and building up the strong or dark parts on the overlay. With a proper overlay the artistic effect of the picture can be much increased; with a faulty overlay it can be quite spoilt. In letterpress printing the artistic element lies in the making ready.

Typographic prints are distinguished by the lines, figures, etc., being somewhat pressed into the paper, and show raised up on the back, which is technically termed "impression." When this "impression" is very plain, that is to say when the printing has gone pretty deeply into the paper, it is advisable before reproduction to remove this by strong pressure.

The second method of printing is exactly the opposite of the first, and is founded on the principle of printing from intaglio. The lines and points which should print are cut mechanically (by engraving or piercing) or chemically (by etching) into the stone. The etched or engraved intaglio plate represents a negative, or a reversed wood-cut, only with the difference that the lines do not

lay in the same plane. In order to obtain an impression the ink is pressed into the cut-out parts, and is wiped off from the surface of the plate. By stronger or weaker wiping the print receives a stronger or weaker local tone, which is of great advantage from an artistic point of view, but which forms no small obstacle to the reproduction.

The impression is represented in relief on the paper. According to the depth of the lines they take more or less ink, and appear therefore raised up in the impression according to the amount of their depth in the plate. Reproduction photography has to reckon on this disadvantage, for with a side illumination the raised up lines cast shadows, and a correct negative does not follow.

By the third method, lithography, of which we have already spoken, the impression lies generally flat on the paper like a drawing, if a very strong deep etching was not used, in which case it is also slightly raised. In printing from the graver or from stone etching a faint relief is generally noticeable, which is never so high as with copperplate printing, and which is no important obstacle to making a photographic negative.

CHAPTER I.

1. General Notes on Photo-lithography.

By photo-lithography we generally understand that process by which it is possible to prepare a printing plate or a stone by the aid of photography from any original, whether it be a drawing, a print, or an oil painting, either of the same size or smaller or larger than the original, which can be reproduced in the lithographic press.

The main characteristic of this process is that either the original from which the reproduction is to be made must be prepared in distinct lines, strokes or points, or that any half-tone which may be present in the photographic negative must be broken up on the stone or plate into lines or points.

The basis for the preparation of a photo-litho is as a rule a photographic negative on glass or gelatine, which, as the word negative implies, when examined by transmitted light, must have all its tones reversed, that is to say, the drawing or the lines, strokes or points which must in the print be black, must look transparent, whilst the other part of the negative which forms the groundwork must be covered or opaque.

If every photo-lithographic process was to be described in detail there would be a great many, but actually they may all be classified according to two principal methods:—

(*a.*) One, in which the stone or plate is itself coated with the light sensitive substance and exposed under a reversed negative, so that a reversed image is formed on the stone or plate, which in printing comes in the right position, and

(*b.*) The other, in which paper or a very thin zinc plate, provided with a light sensitive film, is exposed under an ordinary, that is not reversed negative, and thus is rendered capable of receiving fatty ink, and is then transferred to the stone or plate by transfer.

Of the many processes which, though differing in detail, may, looking to the final result, be assigned to one or other of the above-mentioned principles, there are two which have been especially tested in practice, namely, for *the direct transfer*, as we will call it, that process which is based on the light sensitiveness of asphalt or of an organic substance in combination with a

chromium salt; and for *the indirect transfer*, that process which is founded on the light sensitive chromium salt in combination with gelatine, or briefly on the light sensitiveness of chromated gelatine. All other more or less complicated methods have disappeared from technical practice and have only the honour of being scientifically interesting and theoretically correct, but for various reasons are not practically valuable.

It is indeed obvious that a discovery so important and useful to one of the principal departments of the graphic arts as lithography is, and which may be called even more essentially capable of variation and multiplication, and perhaps in its way also more artistic, should call forth an earnest movement on behalf of the technical experts, principally with the endeavour for simpler forms and extension of its powers of work. This, indeed, has not always been attained, and these attempts will therefore only be taken into consideration in this book as may appear necessary, and all others will be passed over in silence.

The methods used by some experimentalists for direct transfer, which consist in coating the stone with a solution of gelatine, albumen, or gum made light sensitive with a chromium salt, and after exposure under a positive or negative, obtaining a printing plate, were in execution complicated and troublesome, but in results fairly safe and satisfactory, so that they are now more and more used in practice.

Iron and silver salts have been proved as not very suitable for photo-lithography, and at the present time for direct transfer asphalt is most generally used, and latterly also organic substances rendered light sensitive by a chromium salt; for indirect transfer chromium salts in combination with gelatine, or chromated gelatine.

Asphalt exposed to the action of light undergoes a chemical change which consists in its becoming less soluble in its original solvents. This was known to Nicephore Niépce, one of the discoverers of photography, whose endeavours to produce images by the action of light were actually based upon this very property of asphalt. He used for this purpose metal plates which were converted by a species of etching into printing plates.

In the year 1852, the well-known Parisian lithographer Lemercier, in partnership with Lerebours, obtained a patent in France for a process by which they were in a position to obtain images on stone by the exposure of asphalt, and thus reproduce the same by printing in the ordinary way. They coated a lithographic stone with ethereal solution of asphalt, exposed it under a negative and developed it with ether; there remained behind then the parts which had been rendered insoluble by light and formed a positive asphalt image on the stone, the outlines of which had the property of taking up greasy ink and with suitable preparation of giving an impression on paper. Such a stone was etched in the ordinary way with acid and gum, and then it was possible to make as many

pulls from it as was desired in litho ink. We have here a practical photo-lithographic asphalt process, as it is at the present time practised with various modifications, and which gave satisfactory results.

Other resins besides asphalt may also be rendered sensitive to light, and it is well-known that they also may be used with as good results as asphalt for photo-lithography.

That the good qualities of asphalt were even earlier recognized is proved by the fact that Negré, before the discovery of zinc etching, exposed a copper-plate coated with asphalt solution under a negative, washed out the places not affected by light, electro-plated these blank places in a gold bath, then cleaned the plate and deep etched it with acid. He obtained in this way an intaglio printing plate similar to an etching.

By using a positive with this process a relief or typographic plate may be obtained, both of which processes are known as "gold etching," and were practised in the beginning of the '50's in the K. K. Hof-und Staatsdruckerei.

The asphalt which is used for photo-lithographic purposes must possess certain qualities, of which the most important is as high a light sensitiveness as possible. With ordinary asphalt success will not be attained, since it is only slightly sensitive to light; the so-called Syrian asphalt is therefore generally used, which after having been prepared is dissolved in chloroform and then benzole and oil of lavender are added.

Professor Husnik prepares an asphalt from which all constituents not sensitive to light have been extracted. Herr Valenta produces his sulphurized asphalt. Both possess a far higher light sensitiveness than ordinary Syrian asphalt, and are specially suitable for photo-lithography.

The second, and considerably more extensively used method for photo-lithography—a transfer process—is based on the light sensitive property of the chromate salts in combination with gelatine, or albumen, or gum.

That the bichromate salts possessed light sensitive properties, and could be used for photo-lithography, Mungo Ponton discovered in 1839. He printed on an ordinary paper, which had been rendered sensitive to light in a solution of potassium bichromate, drawings and silhouettes, and obtained after fixing, which was effected by merely washing in pure water, brown images on a white ground.

Later Talbot found that the chromate salts in combination with organic substances under the action of light altered the property of the latter, and particularly that exposed chromated gelatine became insoluble in hot water. Poitevin used this discovery for carbon or pigment printing, and had produced in 1855 various pictures with this process.

Poitevin discovered, further, that exposed chromated gelatine

would not swell up in cold water and took up greasy ink, and therefore after exposure under a photographic negative a picture could be obtained exactly inversely corresponding to the tones of the negative ; and that these places affected by light could be inked up and printed from, or could be transferred to a zinc or stone plate, and from this pulls could be prepared. By this discovery photo-lithography and collotype were actually discovered.

Led on by his success, Poitevin used later, instead of gelatine, albumen and gum arabic, and prepared with these photo-lithographic prints, which were transferred to stone.

If a solution of gelatine is mixed with a solution of bichromate of potash, and a sheet of paper coated with this mixture and exposed, or if the paper is first coated with gelatine and then bathed in a solution of bichromate of potash, various chemical changes take place as the result of the action of light on the gelatine film, which we will now consider.

As has already been mentioned, glue or gelatine is insoluble, and only swells up in cold water. In warm water, however, the gelatinous substance dissolves completely, and sets on cooling to a jelly. If a suitable sheet of paper is coated with the warm gelatine solution, either by floating or pouring it over it, and it be allowed to set, and if this film is now made light sensitive in a solution of potassium bichromate and dried in the dark, we shall have a photo-lithographic paper which, according to the greater or less quantity of the chromium salt used, has a more or less intense yellow colour. If the paper thus prepared is exposed to light under a negative, or in another way if some places before exposure are protected by black ink or strips of paper, the places affected by light become dark coloured and brown, and at the same time they have lost their power of swelling up in cold water. The whole surface of the paper, that is to say the exposed and unexposed films before being laid in water, are flat or in one plane ; if, however, the print is laid in cold water the exposed parts are not affected by the water, that is to say they have lost the property of swelling and remain in their original plane. The unexposed parts swell up and appear raised up on the print, and thus make the drawing sunken in.

The exposed places have, however, now received the property of taking up and holding greasy ink, whilst the unexposed have taken up water and repel greasy printing ink.

If the paper be exposed under a negative the drawing appears sunken in after development with water ; the other parts, which must in printing appear white, are raised up ; by exposure under a positive the reverse is the case.

If these prints are in any way, either by rolling up or brushing over, given a coating of greasy ink, the ink only adheres to the exposed places and a print in greasy ink is obtained, which, like any other greasy impression, can be transferred to a stone or a metal

plate, which can be printed from direct, or the transfer may be made on to a metal plate for relief etching, that is to say for the preparation of a typographic block.

In Poitevin's process the stone itself was coated with a light sensitive chromated film, and exposed under a reversed negative. After developing and careful preliminary preparation of the stone the ink only adheres then to the places affected by light.

This is also the case if the stone is coated with light sensitive asphalt, and the same printed on direct. After exposure the parts not affected by light can be washed off with turpentine, benzine, or linseed oil, so that the stone is laid bare; the places, the parts of the drawing affected by light, however, are not dissolved. If the stone is now prepared with the solution of gum as has already been described, and then rolled up with an ink roller, these places will take the ink, and by etching, etc., the stone may be so prepared that the same may be printed from like any drawing or engraving.

By photo-lithography only line or grained drawings can be reproduced, and half-tones, as is possible with collotype and photogravure, cannot be obtained.

Now, with the aid of autotypic transfers and the asphalt process on grained stones, we have a perfectly satisfactory method of reproducing in an excellent manner half-tone drawings by the aid of photo-lithography.

Photo-lithography in all its various branches of application is at the present time so perfected, and rests on so comparatively a simple principle, that a technical printer, with very little practice, experience, and observation of the formulæ given, can attain in very short time absolutely good results. At the same time it must be said that frequently very great difficulties have to be contended with; especially as regards the quality of the materials and negatives great care must be used.

2. Subjects which can be Reproduced by Photo-Lithography.

The next question which arises is, "What can be reproduced or multiplied by means of photo-lithography?"

The answer is, "According to the existing state of the technique of photography and the perfection of the transfer process, everything." Any line or wash drawing, any oil painting or other plastic object, any photograph of living creatures or lifeless objects —briefly, any photograph can, under certain conditions, be transferred to stone or a metal plate, and from this any number of impressions in greasy ink be obtained. Before the discovery of the method of breaking up half-tones into points or dots, only line drawings could be reproduced by photo-lithography. Since, however, it has been possible to break up half-tone into line or points or grain, nothing stands in the way of reproducing by this

method any kind of original. This breaking up of the half-tone into a regular or irregular grain can be effected by means of a crossed line screen in making the negative, as in autotypic, or half-tone, block-making, or independently of the making of the negative, as in the asphalt process of Orell, Füssli and Co., and in Bartös' process and various other methods.

The undesirable half-tone must, however, always be broken up in some way into the requisite points or lines, as it is one of the characteristics of lithography that it is only possible to print from distinct figures on the stone. Lithography and letterpress printing produce impressions of sharply-defined lines or points, each of which must form a distinct whole. Any tone which is lighter or not absolutely black must be formed by lines or points standing in close proximity to one another. The tonality must be formed by stronger or weaker lines or points, by black and white spaces, or by more or less close line and point patterns. An absolutely closed tone, as in collotype or photogravure, is not attainable with lithography, and although numerous experiments have not been wanting to reach this end, the same have hitherto been without success.

The half-tones are broken up and separated into solid printable points :—

(*a.*) By the autotypic transfer, which is effected by placing in front of the sensitive plate when making the exposure the above-mentioned crossed-line screen.

(*b.*) By the so-called asphalt process, by means of preliminary graining of the stone before coating with asphalt and printing.

(*c.*) By means of the production of a grain on chromated gelatine.

(*d.*) By the use of a sand blast, which is the chief point of Bartös' process.

(*e.*) By transfer of a close grating or network on to a polished stone, which forms the basis of the litho-heliogravure process of General-Director Chas. Eckstein, which is included in photo-lithography.

All these methods have for their purpose the breaking up of the light tones into regular or irregular but separate points. There are other methods besides those mentioned above which have the same purpose.

We generally distinguish two kinds of reproduction :—

(*a.*) Those from line drawings, in which a negative is made without the interposition of a cross-lined screen, and for which no other means is used for the production of a grain, and

(*b.*) Those from wash-drawings, paintings, photographs from nature, etc., in which reproductions the half-tones are either broken up into lines or points by the use of the screen when making the negative, or by any of the other above-mentioned means after making the negative.

(A.) Line Drawings.

By the first method the drawing must be prepared according to certain formula if a good negative is to be obtained which shall not require much after work and disadvantages for photo-lithography. A poor original may cause a partial or complete failure of the work, or at least cause much cost and waste of time; therefore it appears advisable to pay the necessary attention to the original which is to be reproduced.

What a line drawing must possess which should be reproduced well by photo-lithography in order to give a good transfer on to stone we will now point out.

Before all things should be noted that the paper must be pure white and smooth, yet not strongly reflective and not too weak. Smooth white cards of medium thickness are the best to use. Since all lines of the drawing appear in the impression of the same colour, there is not only no purpose, but it may even be very disadvantageous to the reproduction when the draughtsman, in order to increase the artistic effect of his work, or to produce good perspective, etc., draws fine lines or other points in a lighter colour. The striving of the artist for effect, perspective, etc., so far as this is attained by lines or parts of a lighter colour, has for this process of reproduction no advantage, but, indeed, the disadvantage that by this the subsequent manipulations are rendered more difficult, the whole work will turn out more costly and finally less satisfactory.

Although from the present position of photography drawings in any desired colour can be reproduced, yet it is most advantageous if the originals for photo-lithographic reproduction are drawn with fine black matt ink on smooth white papers, and the principal point to which attention should be directed is that all lines, even the finest, should be a good black, and should be kept of the same strength of colour as the other parts of the drawing. The thick lines must be quite filled up like the shadow lines of a strong letter. Shading must be obtained by strong, fine running lines quite separate from one another. In this the single black lines must not be too strong, and the white spaces in between must not be too narrow, or otherwise when reduced in size the white interstices will disappear and will finally form a solid tone. The laying on of a tone or wash is not permissible, as even a light tone will appear in the reproduction as a black spot. It is not permissible also to draw on the same original with inks of different blackness or consistency, and even if a coloured ink be used the whole original must be prepared with one colour (red, dark blue, green, or brown), and that as intense as possible. When we start from the only true standpoint, that every reproduction should be a reflex of the original as true as possible, artistic effects have from this point of view no purpose, since the printer in printing with

one ink is not in a position to give grey lines as well as black, but can only give the appearance of everything in one colour only. He is, however, able to give with the strongest line the finest with their own characteristics, and can, therefore, in this direction attain the tonality of the original.

It is obviously, therefore, the artist's duty to draw in one colour, and since for photographic reproduction black is the best, that is to say Chinese ink, he will do well to completely lay on one side all other artistic materials or effects. At the same time it should be noted that originals drawn in any other colour can be reproduced by photo-lithography, but if the drawing is to serve no other purpose than for reproduction it is best to prepare it in black.

A further important requirement is that the drawing be sharply and cleanly worked, and since the reproduction of a ragged or broken line cannot make a full smooth beautifully running line, they will appear in the reproduction in the same defective way, and then require at least tedious retouching or make the printing of the subject actually impossible. If it is necessary to cross the lines in the shadows this must be done with great care. The points of crossing must be clean and sharp, and the ink must not run. Too close or too frequent crossing of the lines should be avoided, and would produce a bad and different effect in the reproduction. Smudges or wrinkles in the original appear in the reproduction more intense and more vigorous, and therefore it must not be forgotten to carefully avoid these, also any tracing lines must be erased, without, however, damaging the ink lines or rubbing up of the paper.

Pencil and chalk drawings, assuming that they are cleanly executed, can be well reproduced by photo-lithography, only they ought not to be smudged or inked. Erasure marks on pencil drawings appear in the reproduction as smudgy spots.

Drawings of architecture for illustration or other purposes, after consideration of these remarks, can be well transferred without much trouble by photo-lithography on to stone or zinc.

In drawings of maps, plans, etc., there are still some rules to be observed besides the above. Boundary lines or mountain ranges with fine hatching, waterlines for large rivers, seas or lakes, as well as the introduction of figures, are better left out of the drawing, and can be afterwards drawn on the stone; they will then be cleaner and sharper. If all these details, however, must be introduced into the original drawing, they should be executed in a pale blue colour, which will not appear in the ordinary negative.

For plans with large letters it is better not to draw the latter, which are frequently a lot of trouble, but to employ the simpler plan of getting the titles, writing, legends, explanations, etc., printed by a book printer on paper of the same colour as the original, and stick them on the latter. The same method may be

adopted when preparing railway, postal, and telegraphic charts or maps with a lot of names or other titles, etc. The network of lines may be drawn with litho ink as suggested above, but the names of the stations, etc., can be printed with letterpress and stuck on in the proper places. Working in this way not only will much labour be saved, but at the same time sharper and more correct titles be obtained on the reproduction.

Any necessary instructions for carrying out the drawing should never be made on the paper with red pencil, but either with pale grey or pale blue. For this paper rubbed with indigo or graphite can be used or a scratched gelatine proof which has been rubbed with finely powdered milori blue.

With commercial drawings it frequently happens that ornaments are repeated. It is not necessary for the designer to draw all the ornamentation, which may frequently be very complicated, if it runs over the whole of the design. It is quite sufficient, according to the size or the number of times that the ornament occurs, for the artist to draw it twice or three times, or sometimes ten to fifteen times; the lithographer will duplicate it by transfer. This also applies if there is a border, or if there are any corner or centre pieces repeatedly used. It is quite sufficient to draw one-fourth of the frame or border, or with very complicated designs a complete corner, and to give the printer a rough sketch of the complete border. He will make the necessary impression on transfer paper by photo-litho transfer on the stone; he will also reverse the drawing from right to left, join up the different parts, and thus construct the whole border. This applies also to the corner and centre piece.

(B.) Drawings on Blue Prints.

As a substitute for a proof cyanotype or blue prints may be used for preparing drawings for photo-lithography and other graphic arts. When a photo-lithograph like a pen and ink drawing is to be prepared from a coloured picture, or from a sepia or Indian ink wash drawing of a plastic object or a photograph from nature, or from an object not suitable for photographic reproduction an autotypic transfer is to be prepared, a proof of the desired object must be first prepared, and then from this the drawing is to be made. It is obvious that the proofs of the first-named can only be made in the original size, which under some circumstances may not be just what is required, assuming that the original can be used in this way. In all cases this will be inconvenient and tedious, and possibly from the nature of the drawing many proofs be lost. The end will be attained far more quickly and safely if a negative is made of the original, either of the same size or enlarged according as may be desired. The negative thus obtained is used to make a ferro-prussiate print.

For this we use a good firm drawing paper, which is sensitized in the following mixture:—

Solution A.		
Potassium ferridcyanide	8	parts.
Water	150	„
Solution B.		
Ammonio-citrate of iron	10	„
Water	100	„

When dissolved each solution is filtered and mixed in the dark room immediately before use in equal parts. The solution thus formed is sensitive to light and is spread on a well-sized drawing paper as evenly as possible with a broad brush, equalized with a distributing brush, and then dried in the dark room.

The coated side of the paper appears yellowish. It is then printed as usual until the deepest parts look grey, as the prints look weaker after developing. The prints are developed by floating them face downwards on a dish of pure water not too cold, and then washed till the drawing appears quite white on a blue ground. The washing must be thoroughly done or else the prints turn blue afterwards when exposed to light. These prints contain all the finest details, even in the deepest shadows, plainly visible, and will now be the most perfect and most convenient proofs for the artist. The tracing or drawing is now done with good black dull surface ink as already suggested. When the drawing is done it is allowed to dry thoroughly, which will be in from two to three hours. The following solution should be prepared:—

Oxalic acid	1	part
Water	10	„

which should be poured into a flat dish and the drawing allowed to lie in it for about thirty minutes. It is then again well washed and then immersed for fifteen minutes in a bath of

Hydrochloric acid	1	part
Water	20	„

The blue colour will now have disappeared, and the ink drawing will appear pure black on the white paper. It should be now hung up and dried in the ordinary way. This drawing prepared in wash or line with ink now forms the original for a further photographic negative, which is made in the correct size of the reproduction with or without the intervention of the crossed screen according to the character of the drawing. With the negative thus obtained a photo-litho on stone or zinc, or a typographic copper or collotype plate, or a photograph on wood for xylography may be prepared.

The use of this process appears specially important for those cases in which an ordinary photographic negative is not sufficient,

for example where a printing plate cannot be prepared from the negative. It ought also to be useful when the light could not be controlled in making the negative, and thus incorrect effects appear in the reproduction, which often occurs in negatives from nature and with polished plastic metal objects. The enlargements from the original are then used because the details can be better seen, and the artistic character can be more easily seen. The fineness of the drawing must obviously be in proportion to the after reproduction, while tones may be partly or entirely lost.

(c.) Drawings on Prepared Papers.

For photo-litho transfer without the use of a screen there are some commercial papers, toned, grain, net or pyramid grained papers which may be used with excellent results.

On these papers, according to their preparation, various excellent results can be obtained, which possess high claims as illustrations.

A smooth white scraper board made by Angerer and Göschl of Vienna, which has a very even film of chalk, and which takes the lines clean and vigorously, is especially suitable for pen and ink work. On this paper plucky drawings like woodcuts can be executed. The perfect whites of the paper, combined with the vigorous beautiful black, facilitate reproduction with excellent results and without much trouble.

An ordinary writing pen and ordinary Chinese ink are used for drawing. The ink gives sufficiently black and matt lines.

The deepest parts are covered with ink, and the desired shading or stippling put in with the toothed scraper or engraving tool. The shading off of the shadows may also be worked up with the toothed scraper, and thus very delicate shading be obtained.

Two more very useful papers by the same firm are known as scraper boards with printed lines or points, and white scraper boards with simple or double lines stamped on to it. These papers are also coated with a chalk film.

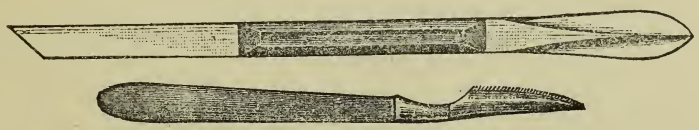

Fig. 1.

With these papers the printed lines or dots serve as half-tones for the artist, and by scraping with smooth or toothed scraper knives very many effects can be obtained. Lead pencil, chalk or litho ink can be used for drawing. For laying on, ordinary ink with a small addition of soap may be used, and new tone effects

may also be produced with a half dry Chinese ink brush, but for any drawing for line reproduction washing with paler or darker inks is excluded. By scraping with the smooth scraper, points are formed in place of the lines, which by further scraping disappear entirely into white, by which means the transit into the highest lights is effected. If a black surface is scraped with the smooth knife a line tone is produced in the opposite direction to the printed one. By the aid of the toothed scraper lines in any desired direction can be obtained. When the printed tone is only desired in parts in the picture, the other parts can be covered up with white paper. The paper is only stuck down by the edges with mouth glue; if it were stuck down all over with gum or starch it would be distorted. On the white paper stuck on, drawing may be done with the pen, and thus new effects again be obtained, as thus in a manner pen and wash drawing are combined.

The white scraper boards without printed lines or dots are either impressed with a single line or with lines crossed at right angles.

On this paper pen and ink drawings combined with grained tones may be done. The outlines and everything which is to be treated like a pen drawing may be done with a hard pen or a marten brush. Bright tones are so worked with the brush that smooth surfaces are not formed, but dotted darker or lighter tones. Those parts which have been laid on quite black can be brightened up afterwards with the smooth or toothed scraper knife or the needle, and thus many gradations obtained. Instead of the litho writing ink pastell or very black good litho chalk may be used for drawing. Obviously this paper also ought not to be washed or smeared.

The pyramidal grain paper prepared by Schäuffelen of Heilbronn is also very suitable for drawings for photo-lithographic reproduction. The paper is coated with a chalk film of blinding whiteness, and is stamped with a regular grain of truncated pyramids, and is produced in three numbers. Grain No. 1 contains 2,500 regular projections per square centimetre; grain No. 2 contains 1,500; and grain No. 3, 750 pyramids.

This paper is drawn on with litho chalk or black pastell crayons. The deepest shadows are laid on quite black, and light effects are introduced with the scraper or engraving needle as with the above described papers. The same rules apply to the other parts of the drawing.

For drawing in general or the use of effects in drawing it should be noted that with all these papers the drawing may be somewhat overdone, and this is necessary in order to obtain the corresponding vigorous action in the reproduction. The printing ink is, as a rule, never such a deep black as the drawing ink, nor is the paper which is used for printing ever so white as the lines of the toned paper. The contrasts would, therefore, in printing become too

little, and flat unsatisfactory pictures would be obtained. With these drawings, therefore, the two opposites, "black and white," may be used to the extreme, even if the drawing is not satisfactory to the artistic eye.

For making the drawing red paper ought not to be used, as when photographed red appears dark. Then blue proof paper, or paper rubbed with lead pencil, should be used.

A drawing for photographic reproduction ought never to be rolled, and still less be folded; if it is to be sent away it should be packed flat.

(D.) Reproduction of Prints.

It is frequently required to make photo-lithographs of old prints As already mentioned in the introduction, we distinguish three different methods of printing, of which the two first, typography and lithography, are confined to the rendering of well-defined lines or points, whilst copper-plate printing can to a certain extent reproduce lines and tones. As regards the reproduction of the first two, so far as their fundamental character goes, no insuperable difficulties present themselves, when they correspond at least to the general requirements of a drawing. Since a reproduction, with exceptions, can never be better—obviously without very complicated retouching—but always somewhat inferior to the original, the appearance of the original will always be some guide as to the quality of the reproduction that can be produced.

If, however, prints are prepared specially for this purpose, the following points should be observed :—

1. For printing a matt surface a so-called pure white chromo paper should be used.

2. The ink should be black and of good body, the impression clean and sharp, every line exact and not in the least fuzzy.

The expert lithographer will easily prepare his impression. Assuming that he has a good original stone, he will more easily make good and correct prints from the engraving from the chalk, pen or other drawing than the typographer. The latter has to give his impressions the correct finish by means of overlays, without the correct making and use of which no good picture, whether it be characters or a drawing, can be obtained actually on a typographic press. The reader is referred to my article in Professor Eder's "Jahrbuch für Photographie und Reproductionsverfahren" for 1891, where I have treated of this at length. Prints produced by the third method, copper-plate printing, give far greater difficulties to the photo-mechanical worker. Every pull from the engraved plate—etching scraper drawing and photogravure excepted—possesses a tone on its surface, which is, moreover, very unequal, and although increasing its artistic qualities, offers, however, considerable difficulties for reproduction. This can

only be avoided by very troublesome retouching, which is frequently prejudicial to the beauty of the picture.

If pulls are specially prepared for reproduction the copper-plate printer must very carefully polish his plate and print without a tone, but still this must not be done so that the plate is too strongly polished that the depths lose their vigour; this would give an absolutely incorrect picture as regards gradation of tone.

Etchings can, as a rule, only be reproduced with the aid of a cross-grained screen, and the same applies to photogravures, although the latter will seldom be required.

All tone or painted originals, such as wash or sepia drawings, photographs from nature, collotypes, photogravures, water-colours and oil-colours can only be reproduced by photo-lithography by the interposition of a screen when making the negative, or by a process in which the breaking of the tone is effected independently of the photographic negative, and which will be described later on.

With old photographs which have faded it is as well to increase the lights and shadows by painting.

(E.) Size of the Reproduction.

A question frequently asked is, "Of what size should a drawing be made in order to obtain a good photographic reproduction?" This question cannot be precisely answered, for a good deal depends upon the object itself, and on the kind of drawing.

It may be generally said, however, particularly as regards pen and ink drawings on smooth paper, that they should never be smaller, only very rarely of the same size; they should be drawn one-third or one-half larger generally. The artist can execute fine details more easily and precisely on a large drawing than on a small one.

The enlarged reproduction gives any faults or mistakes which may happen to be in the drawing in proportionately larger size quite independent of the fact that an enlarged reproduction is always somewhat rough and ordinary. Reproduction in the same size reproduces the faults the same size as they exist in the drawing; the reduction, however, also reduces the failings of the drawing if it cannot also absolutely remedy the same. The reduced copy has always something finer and more delicate. The degree of reduction must be kept in mind, and the drawing be done with this in view.

If a drawing is executed very finely and full of detail, and, besides that, contains very small lines of drawing or titles, they do not gain in reduction, but the opposite; they lose, as much that in the drawing appears plain and distinguishable becomes by strong reduction indistinct and unrecognizable, or appears to the eye as a tone.

Individual cases, in which for specimen purposes or to show how far reduction can go, many times linear, five, six, to ten times, cannot be taken into consideration, although the effect is usually well attained.

It should also be observed that the drawing must be considered not only as regards its size, but also the strength of the lines and tones generally for reduction; this specially applies as regards the tones. By reduction the tone gradations are compressed, the picture becomes poorer in tones, and although, theoretically considered, light and shadow, that is to say black and white, are actually distributed in the same ratio as in the original, yet the reduced image appears proportionately darker and loses in artistic effect

Great reductions will, however, be useful when for some special purpose such as the exact reproduction of geometrical figures or surface ornaments are required, as for instance in printing designs for cheques, bank notes, etc. In such cases the drawings should be made as large as is necessary for the most exact and easiest carrying out of the figures, as in this way the precision of the drawing is better kept by reduction. In such cases, assuming that the ornaments are clear and open without shading, the reduction may be carried beyond one-tenth linear.

This kind of reproduction should present no difficulties either to the reproduction or printing.

It is quite different, however, with drawings on scraper boards or grained paper. If it is kept in mind that with too great reduction the gradations of tone of the print will be destroyed, and that in the same degree the difficulties of printing will be increased, care should be taken that reduction is not carried too far. When it is further considered that in a reproduction with 2,000 to 3,000 points to the square centimetre the individual points disappear to the unaided eye, and the different thick layers of points appear as closed tones, the limit of reduction will soon be found.

If we reckon according to this view, we can assume that those kinds of paper with coarse grain should be reduced at the most one-third, those with a finer grain a sixth, at the most a fourth, in order to obtain good printing plates which will give large editions. In this obviously will a good deal depend on the character and more or less rich in detail execution of the drawing. Still there are photo-lithographic processes such as the asphalt process of Orell Füssli & Co., which contains about 15,000 points, and Bartös' process, which contains 11,000 points to the square centimetre; still for reproduction in large quantities these processes offer many difficulties, and cannot therefore really be taken into account when considering this.

CHAPTER II.

THE PHOTOGRAPHIC PROCESS.

1. The Studio.

The arrangement of the reproduction studio is essentially different to that for ordinary portrait work. The general points of such arrangements are described in detail in the handbooks of Drs. Eder and Vogel, and these I may therefore omit so far as nothing novel is to be observed.

We distinguish now between daylight and artificial light studios; further, those in which a camera is used for making the negative and those in which a dark-room itself is the camera. The first will, of course, be used where other things besides reproductions have to be made; the arrangement without a camera presents many advantages for reproduction work only. In the arrangement with artificial light the illumination of the object to be taken is effected as a rule with a source of light which can approximately replace daylight, and which also remains as constant as possible, and the electric light is at present the best. Although other sources of light are sometimes used, the electric light in the form of the arc light for continuous practical use has the advantage. For copying oil paintings daylight is to be preferred under all conditions, and for this the best arrangement is the revolving studio.*

The description of a modern studio with electric light as used in the K.u.K. Militar-geographischen Institut in Vienna, and from which the studio of the K.K. Hof-und Staatsdruckerei was copied, is given here. This studio lies seven metres below the level of the street on the south front of the building, and is shown in Fig. 2.

The preparation and dark rooms are illuminated with white, yellow, and red light by means of two 50-c.p. incandescent electric lamps for each colour, and besides this are provided with window screens of glass of the same colours for daylight.

The windows open into an area 50 cm. wide which runs round the building. The lighting is so arranged here that besides the ordinary collodion plates, very sensitive gelatine plates can be worked. The room C, where the original is placed, is fitted up

* See Eder's "Jahrbuch für Photographie," 1893, p. 231.

with four Franzen arc lamps of 3,000 c.p. each for illuminating the original, and the lamps are so arranged that the light falls centrally on the original. The four lamps are fastened by ball

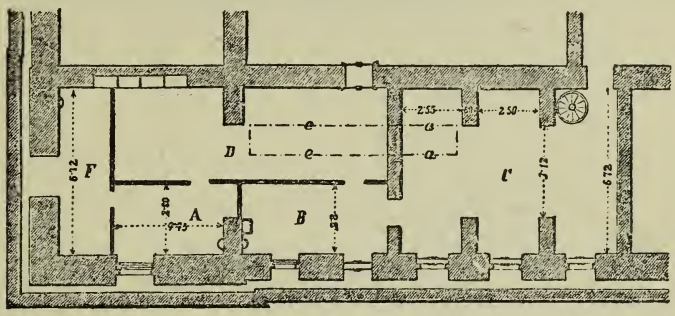

Fig. 2.

A is the room for the preparation of the plates, for the wet collodion plates, and the silver bath.
B the developing room.
C is the room in which the original is placed, where is found a support for the original TT', as is shown in Figs. 3 and 4.
D is the dark-room with the focussing table EE' (Figs. 2 and 3), and is separated from C by a wall of 15 cm. thickness. In this wall is found the photographic lens in a metal flange built into a stout iron box.
F is the washing and polishing room for the glass plates.

and socket arms to an iron frame which rests on rollers; they can be raised or lowered on the frame, and for taking small objects can be pushed closer together. The arms are fastened to the round pillars of the frame, being provided with a screw grip. The lamps can be placed as close as 0·5 m. to the original. As a rule, however, they are worked at a distance of one metre, as then the intensity of the light is about equal to diffused daylight. The axes of the carbons in the lamps are so arranged that the glowing crater formed in the positive pole is turned to the original, by which means the illumination is intensified. The positive carbons have a diameter of 20 mm., the negative carbons 8 mm. The lamps stand in pairs one above the other at LL'. In the two upper lamps the positive carbon is at the top and the negative carbon below it, so that the light is equally distributed over the whole of the subject. With this arrangement of the lamps all reflections are avoided, and neither the grain of rough drawing paper, the relief of an engraving, nor the edges of pieces stuck on are felt. The current is produced by a dynamo in the house; it enters into the place at N, whence it is divided into two circuits of 20 ampères, in which are two switches, an ammeter and a rheostat, and the two lamps on either side.

The wall in which the objective O (Figs. 3 and 4) is placed, as also the brick socle *aa* and *ee* (Fig. 2), on which the support for

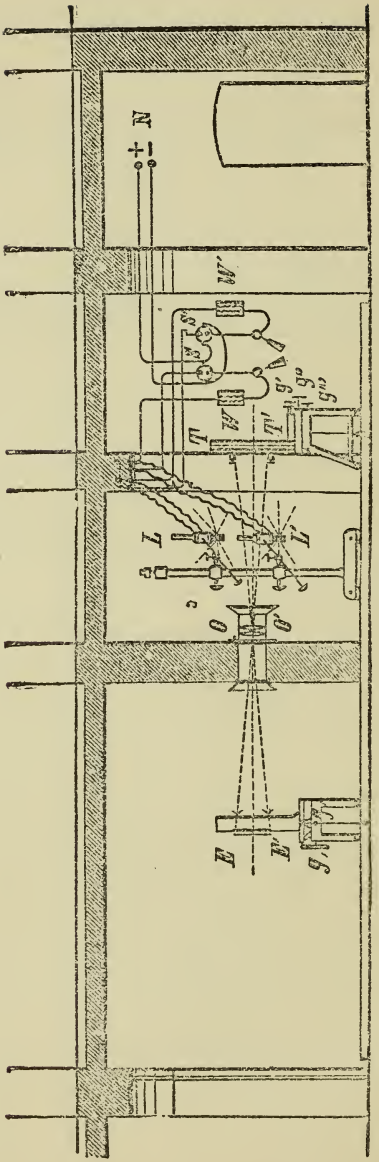

Fig. 3.

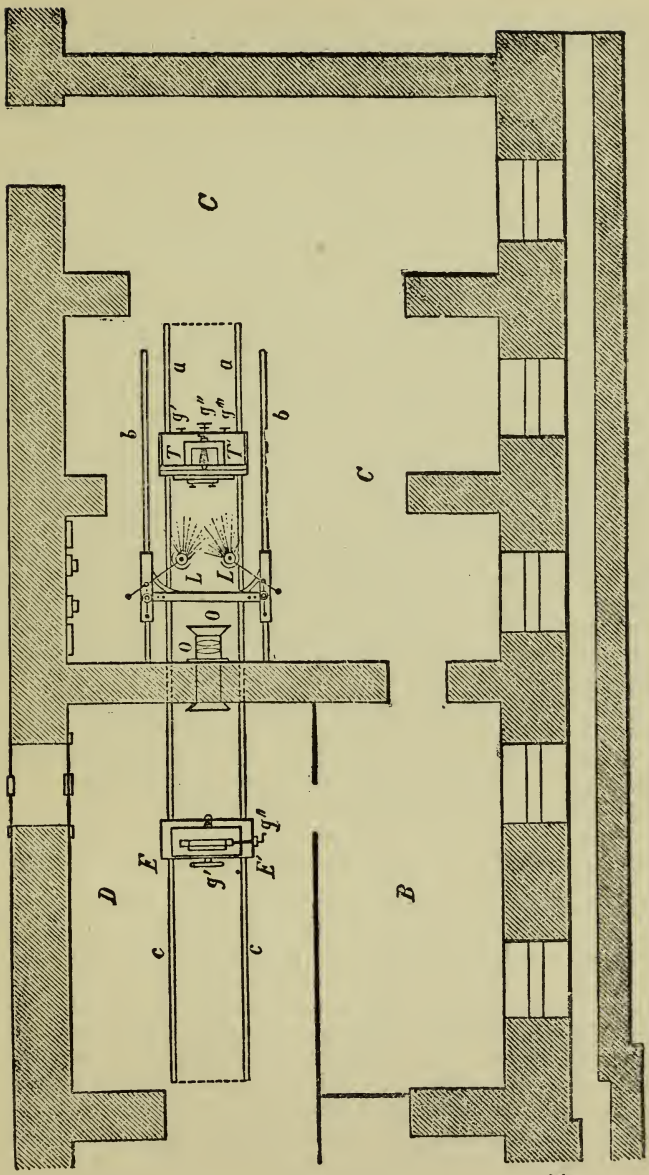

Fig. 4.

the original and the focussing screen rest, run on rails, and are absolutely isolated from the brickwork of the building in order to avoid any possible vibrations.

The stand for the original TT′ is provided with screw fittings, cams and wheels, which make it possible to raise the original, to lower it, to move from right to left, and *vice-versâ*, vertically and horizontally, so as to place its centre axial with the optical axis of the lens, as well as parallel to the focussing screen in the dark room. The whole of the mechanism lies at the back of the stand, so that there is absolutely nothing in front of the original.

The focussing table EE′ is constructed in a similar manner to the stand for the original, and is movable in every direction in the same way. It carries in front two wood clips, in which the board with the original is placed. The table for the original, like the focussing table, is constructed on rollers, which run on the already-mentioned rails. In order to be able to fix these as soon as a sharp focus is obtained a brake is fitted. The placing of the original table at the distance from the lens is accommodated according to the size in which it is to be reproduced, and has already been estimated. There remains, therefore, only to trouble about the fine focussing, which is very quickly effected.

For taking line or wash drawings and for enlargements up to 80 × 80 cm. a Steinheil wide-angle aplanat is used, which gives no distortion. The duration of exposure is with such subjects from eight to ten minutes. For smaller subjects, and principally for photographs on wood, an orthoscope by Voightländer is used, and the exposure varies from four to six minutes.

A Zeiss anastigmat is used for making autotypes. Duration of exposure from three to five minutes. Coloured objects, oil paintings, etc., are taken in the daylight studio. They are printed in the daytime in the open air, and in bad weather or under pressing circumstances in the night by the electric light.

2. The General Qualities of Negatives for Photo-lithography.

The negative for photo-lithographic work, for whatever method it may be used, must before all things possess two principal qualities; when looked through it should be as clear and as clean as possible, on the other hand the ground as well covered as possible. The deposit must not be of a black colour; from a well-drawn original absolutely satisfactory negatives can be prepared without the black colour. When a drawing is reduced which contains grey lines, dots, and points, as well as full black ones, toned lines will be visible as well as the transparent; with careful treatment, the negative may be so far corrected that it may be used. If this is not effected, or is not possible, the retouching on the stone will be somewhat troublesome. The toned lines print later than the transparent; these will therefore be overprinted

when the former have scarcely reached the correct degree of printing. The choice is then only left either to weaken the lines which are too strong or to draw afterwards the faint or not printed lines.

If the ground is not sufficiently opaque it will print through. This can be remedied by intensifying the negative, or when this is not possible to paint over it as well as possible.

Transparent spots are formed on the negative by an impure silver bath or by dust flying about the room. These must be spotted out if increased work later on on the stone or zinc plate is not desired.

In reproducing fine copper engravings, it generally happens that the fine grey hair-like lines and the light interstices, if the plate was not properly polished, appear less transparent in the negative than the other parts of the picture. In developing the print the result is a partly broken image which can only be retouched with considerable trouble. The negative can be corrected by taking care to paint over the transparent parts. Professor Husnik recommends, when the picture is not too large, to fasten a transparent paper on the back of the negative, and to cover over the glassy places with a soft lead pencil. These parts then print simultaneously with the hair-like line and develop also equally. If, however, the negative is large, and the picture very complicated, a glass positive picture is prepared in the following manner: A polished sheet of glass is levelled and coated with the following solution :—

Gelatine	6 parts	by weight.
Sugar	1 part	„
Ammonium bichromate ...	1 „	„
Water	80 parts	„

When the solution has dried the glass plate is laid on the negative and exposed till the deepest shadows have printed, and it is then developed in water. When dry this glass positive is laid on the back of the negative so that every part of each picture fits. The plates are then bound round the edges with paper strips so that they cannot shift. By this—although somewhat troublesome—operation can an unsatisfactory negative be rendered more even.

This correction can also be effected in the following manner: The back of the negative is coated with raw collodion which is faintly coloured with aniline red, eosine or fuchsine, allowed to dry, and then with an engraving needle or a narrow knife the less transparent lines may be scraped out, so that the red collodion only remains on the transparent places. Obviously also this can be done in the reverse, by painting a faint red on the transparent places with a brush.

By this last method a tolerably extensive retouching may be

effected on unequal negatives, which are the result of not quite equally black or also very close drawn originals, from subjects with very fine lines, such as copper-plate engravings, or from finely-executed lithographs with very great reduction. Finally it should be mentioned that with intelligent retouching any bad negative can be used for photo-lithography, and the only question now is whether it is not better to take the shortest way and prepare a suitable negative when the original really permits of its being done. In printing on chromated gelatine paper a good result can be easier attained from somewhat foggy or thin negatives than by printing with asphalt or other light sensitive substance.

The following kinds of negatives are used for the various photo-lithographic processes :—

For the transfer process with chromated gelatine paper or direct printing on stone or zinc direct, a reversed line or autotype negative.

For Orell and Füssli's process, a reversed ordinary half-tone negative.

For Bartös' process and for photogravure on stone, a direct ordinary half-tone negative.

3. Preparation of the Direct Glass Negative.

The preparation and cleaning of the plate glass is as follows :— First of all the plates are roughened with a piece of sharp pumice stone on the extreme edges to the breadth of about 0·5 cm. in order to prevent the frilling or floating off of the collodion film. This is very little trouble considering the advantage it offers. After being edged the plates are placed in a solution of

Nitric acid chemically pure ...	1 part
Water	10 parts

Instead of nitric acid, chromic acid may be used, but this is not absolutely necessary.

After one or two hours the plates are taken out of the acid bath, well washed under a strong water rose, and dried in a place free from dust. Then the plates are well rubbed with 1 : 10 tincture of iodine solution with a pad of clean filter paper and then polished with 50 per cent. alcohol. This preparation must be done with absolute accuracy, and thus they make all substrata of albumen, india-rubber solution, etc., for direct negatives unnecessary.

Plates which have been previously used are placed in pure water till the collodion film has become loose, and are then scrubbed with a stiff brush, treated for some hours to a bath of caustic soda, and then treated as above, when they may be used again.

For reproduction of simple line drawings iodized collodion is used which consists of 2 per cent. raw collodion composed of—

Ether	1,000 ccm.
Absolute alcohol	1,000 „
Pyroxylin	40 g.

Iodizing is done with

Sodium iodide	15 g.
Cadmium „	15 „
„ bromide...	8 „
Potassium iodide	1 „

The last salt is dissolved in a few drops of distilled water, the other salts are dissolved in one part of the absolute alcohol. The iodizing solution is filtered into the raw collodion, which has already been allowed to settle and filtered, and allowed to stand for some days.

The sensitizing solution is nitrate of silver in the proportion of 1 : 10, with larger sizes 1 to 12—1 to 14, and the silver bath is faintly acidulated with chemically pure nitric acid.

For a monochrome subject the exposure lasts according to the size of the reproduction, and the rapidity of the objective, from three to ten minutes.

For development an iron developer is used, consisting of :—

Water	4000 ccm.
Ferrous sulphate	150 g.
Copper sulphate	75 „
Alcohol (40 per cent.)	250 ccm.
Glacial acetic acid	125 „

The iron developer, with addition of sulphate of copper, is to be preferred for short exposures to iron and lead developer. If the plate has been correctly exposed the image gradually appears after a short time, and very soon gets vigorous. When the details appear in the deepest shadows the development must be immediately stopped, otherwise fogging will ensue. If the image does not gain vigour by long development it was under-exposed; with over-exposure the image appears quickly and remains thin. The developer, when fresh, works fairly quickly; older developers work slower, but give very clear negatives.

For very fine line drawings or reproductions of copper-plate engravings the developer is used somewhat weaker, and one-fifth of its volume of water added. The development takes somewhat longer; the fine lines remain, however, very clear.

After developing the plate is well washed and then intensified first with a solution of —

Water	5000 ccm.
Ferrous sulphate	180 g.
Citric acid	90 „

to which a few drops of a 1:12 silver nitrate solution have been added. Care should be taken that in the first intensification the glassy places remain clear. When, therefore, the desired opacity is attained the plate should be immediately washed. Too long intensification fogs the finer lines.

The plate should be fixed with 5 per cent. solution of potassium cyanide. For this, however, a concentrated solution of hypo-sulphite of soda can be used.

After well washing, the negative will show, when examined by transmitted light, whether the ground is opaque enough, or whether a further intensification is necessary. With correct manipulation this first intensification will be sufficient for fine, well-prepared drawings.

If, however, the opacity proves to be too little, after thoroughly well washing, the second intensification or blackening is effected with a concentrated solution of mercuric chloride in distilled water, which is allowed to act till there is a distinct precipitate and the film has become grey. After well washing the plate is flowed over with solution of thiosulphate of gold till the grey quicksilver precipitate has become absolutely black. The gold solution consists of —

(A.)	Distilled water	1000 parts
	Chloride of gold	1 part
(B.)	Distilled water	1000 parts
	Hypo-sulphite of soda	10 „

Immediately before use solution A is added with constant stirring to solution B, and a few drops of ammonia added. If the desired blackening is not effected with one application the operation must be completed.

The solution of gold, when kept in the dark, will keep a long time.

For fixed negative the following intensifiers have been used with good results :—

1. Intensifier with pyrogallol.

(*a.*)	Silver nitrate...	5	parts by weight
	Distilled water	75	„ „

To this solution is added —

(*b.*)	Citric acid	5	parts by weight
	Distilled water	75	„ „
(*c.*)	Pyrogallol	1·25	„ „
	Distilled water	150	„ „

2. The hydrochinone intensifier recommended by Baron Hübl :—

Hydrochinone	10	parts
Water...	1000	„

To this as much acid is added as will keep the solution clear for

five minutes, when it is mixed with a third of its quantity of 1 : 30 solution of silver nitrate. The addition of a few drops of sulphuric acid or 5 parts of citric acid is generally enough. This intensifier acts somewhat more delicately than the silver and iron solution, and has the advantage over the pyrogallol that it can be applied as frequently as desired in full daylight to the fixed negatives without any danger.

3. The metol intensifier.

The negative should be developed with the above-mentioned iron solution:—

(A.)	Metol	15 parts
	Citric acid	10 „
	Distilled water	1000 „
(B.)	Silver nitrate...	10 „
	Distilled water	100 „

The negative must be fixed before intensification with hypo and well washed.

A small quantity of solution A is poured over the negative to drive off the water, and then it is intensified in the ordinary way with 10 parts of solution A and 1 part of solution B.

Further intensification is effected, as described, with mercury, the blackening with thiosulphate of gold.

When the negative is finished and dried it is coated with a solution of gelatine 1 : 50, or a 1 : 15 solution of gum, in order to protect the film, and the negative should be levelled and allowed to dry.

Good opacity in the ground and clear glass in the lines of the drawing are the fundamental requirements of a negative for photolithography. But drawings are not always prepared in such a manner that this can be completely obtained. With flat drawings which are drawn in grey instead of black the first intensification is only continued till the finest lines appear clear. For further intensification the negative after drying is given a coating of a light sensitive solution of—

Gum arabic	... 17.5	parts by weight
White sugar	... 17·5	„ „
Potassium bichromate	... 5·8	„ „
Glycerine	... 1·8	„ „
Water	... 35	„ „

Ammonia is now added till a light colour is formed. After drying it is exposed from the glass side to 15° Vogel's photometer, washed for about a quarter of an hour and then soaked in warm water till a relief is formed. By this operation a transparent relief is formed on the lines of the drawing, which absolutely protects the same from fogging. The intensification is then effected with mercuric chloride and chloride of gold, or an intensifier of solu-

tions of uranium and ferridcyanide is used, which is composed of two solutions —

(A.)	Uranium nitrate	8	parts by weight
	Sugar	8	„ „
	Water	350	„ „
(B.)	Potassium ferridcyanide	8	parts by weight
	Sugar	8	„ „
	Water	350	„ „

The negative is first flooded with the uranium solution and then with the red prussiate.

Another process of intensification recommended by Prof. Eder and Toth is the so-called lead intensifier.

The somewhat under-exposed negative ought only to be developed with iron, fixed with hypo, and must then be well washed. It is finally well rinsed with distilled water, and then placed in a filtered solution of—

Lead nitrate	4	parts by weight
Potassium ferridcyanide ...	6	„ „
Distilled water	100	„ „

After a few minutes it becomes absolutely opaque in the covered parts. The negative is allowed to remain in the bath till it has attained the desired density. On the silver molecules of the image a pale yellow precipitate has formed by the action of the lead bath. The ferridcyanide of potash is reduced by the silver to yellow ferrocyanide of potash, and gives then, with the lead salt, an insoluble compound, ferrocyanide of lead. By the action of ammonium sulphide the unstable lead salt is converted into a stable salt.

As soon as the negative has been taken from the lead bath and well washed, till the washing water no longer gives a blue precipitate, it is flowed over with dilute ammonium sulphide 1 : 5. Sodium sulphydrate may also be used. The image becomes black instantaneously. The negative becomes generally vigorous ; if, however, it was exposed too long the fine hair lines and points veil over very easily.

If the negative is not sufficiently intensified, which may happen with very much under-exposed negatives, it should after well washing, and before treating with ammonium sulphydrate, be laid in a bath of—

Cadmium sulphate...	10	parts
Distilled water	100	„

in which it becomes still whiter, and should then be treated with the ammonium sulphide. The lead, the cadmium, and the silver of the bath are converted by the ammonium sulphydrate into sulphide. The negatives treated with cadmium have a yellowish tinge, whilst those treated with lead are pure black. For clear-

ing up the white-lead image when it is too vigorous or is foggy hyposulphite of soda or a dilute solution of potassium cyanide can be used. This manipulation, however, requires great care. The negative treated with ammonium sulphide if foggy can be cleared up with hydrochloric acid, used weak and repeatedly poured on and off, with careful watching of the action. After this it must be well washed.

The lead solution will remain clear for weeks, and if it begins to work slowly can be freshened up with addition of lead nitrate and ferridcyanide of potash.

If stripping negatives are to be prepared, it is advisable, with the lead intensified negatives, to give the glass plate a preliminary rub with vaseline oil, to well wash, and then to coat with raw collodion.

Husnik's graphite intensification is still to be mentioned, which, in some cases, may be of great service, but requires practice and care.

The expert photo-mechanical worker will adopt one or the other methods for his work, and as soon as he can work safely and without hesitation he will adhere to that.

4. The Preparation of Autotype Negatives of Black and Coloured Drawings.

As regards the preparation of autotype negatives from simple black originals—wash drawings—the above photographic processes are quite sufficient. For taking painted originals—such as oil paintings, water-colour drawings, fresco, and pastell drawings—an orthochromatic collodion must be used if a correct rendering of the tones in the negative is to be obtained.

In our studio we have obtained excellent results with two kinds of colour sensitive collodion. These are the isochromatic collodion emulsion prepared by Dr. E. Albert and that suggested by Major von Hübl. In using the former, the glass plates as soon as they are taken out of the acid bath and well washed must be given a substratum of the following solution :—

White gelatine	5 parts
Water...	500 ,,

to which is added—

Glacial acetic acid	15 parts
Alcohol	10 ,,

The solution should be filtered and coated whilst warm, and the plate dried in a room free from dust at least 15° R.

For the production of the sensitiveness, or for the production of the correct reproduction of the colours, two eoside of silver dyes, R. and P., are used. The P. dye gives great sensitiveness, and is especially suitable for portraits, landscapes, etc. In using this a

correct reproduction of the red must be abandoned, whilst the R. dye gives an absolutely correct colour rendering but requires about double the exposure Ten ccm. of the eoside of silver solution are added to 100 ccm. of the emulsion. When coloured the emulsion will only keep for one or two days.

The time of exposure with the R. dye is normally from one-and-a-half to three minutes.

After exposure the plate must be well washed under a tap and then allowed to thoroughly drain, or otherwise developing streaks will show.

Hydrochinone developer is used for developing, consisting of three solutions :—

(A.)	Distilled water	500 parts
	Sodium sulphite	200 „
	Potassium carbonate (pure) ...	200 „
(B.)	Hydrochinone	25 „
	Alcohol (96 %)	100 „
(C.)	Ammonium bromide	25 „
	Distilled water	100 „

This developing liquid is concentrated, and is used as follows :—

Solution	A.	100 parts
„	B.	5 „
„	C.	7 „

To obtain hard negatives solution B is increased from 1 to 5 times. A mixture of 150 parts of the above solution with 1000 parts of distilled water forms the actual developer. By the addition of more concentrated developer or increasing the quantity of water the developer may be suited to the character of the subject. The developer must be freely flowed over the plate, and then the plate fixed with sodium hyposulphite. Intensification is effected with—

(A.)	Pyrogallol	7 g.
	Citric acid	7 „
	Distilled water	1500 ccm.

and when dissolved

	Glacial acetic acid	25 drops

are added.

(B.)	Silver nitrate	10 g.
	Distilled water	100 ccm.

Immediately before use 100 parts of solution A are mixed with 5 parts of solution B, and the intensification continued till the desired density is obtained. Negatives can be reduced by placing them whilst damp in a solution of—

Potassium permanganate	1 part
Distilled water	300 parts

When this has acted sufficiently, the plate is well washed,

flowed over with a five per cent. solution of potassium cyanide, and then well washed. When the dyed emulsion is used this must be done, after developing, in red light.

A very excellent method of preparing an orthochromatic collodion emulsion has been described by Hübl,* which can be used either wet or dry. Repeated trials made in the Imperial Military Geographical Institute, in our establishment, and in the Photographic Institute in Vienna have proved the advantageous use of this method for orthochromatic work. The raw emulsion, according to Hübl, is prepared as follows:—40 g. of silver nitrate are dissolved in 50 ccm. of warm distilled water, and as much ammonia added as will give a clear solution; then 100 ccm. of alcohol are added and the whole allowed to cool. 30 g. of ammonium bromide are dissolved in 35 ccm. of water and 70 ccm. of absolute alcohol with gentle heat.

To make the emulsion 450 ccm. of four per cent. raw collodion are placed in a strong glass flask which will hold a litre, and to this in the dark room the silver solution added. Some of the wool separates out, but by vigorous shaking this can again be dissolved. A part of the silver salt also remains suspended in the liquid in the form of fine crystals. The ammonium bromide is added in three or four parts whilst warm. After shaking thoroughly for several minutes the emulsion is precipitated by distilled water, which is repeatedly added till the separation is complete. The emulsion, which is now powdery, is placed on a linen filter, washed several times with distilled water, squeezed to press out the last of the water, damped two or three times with alcohol, and then pressed. Whilst still damp with alcohol the emulsion is dissolved in from 800 to 1,000 ccm. of alcohol and ether, mixed with 0·5 grs. of codeine, and allowed to rest for some days, when it will be ready for use.

The preparation of the eoside of silver solution is effected as follows:—10 g. of yellow-shade eosine are dissolved in 250 ccm. of boiling water and 5 grs. of silver nitrate in 50 ccm. of water added hot. The solution is allowed to settle, then filtered, and then washed first with boiling water and then with alcohol on the filter, and then dried in a dimly-lighted room.

To prepare the dye solution 0·5 g. of the dry eoside of silver and 1 g. of ammonium acetate are gently heated together in 30 ccm. of alcohol till dissolved, then 120 ccm. of alcohol and 10 ccm. of glacial acetic acid are added, and the whole filtered. For plates to be exposed wet, 5-10 ccm. of glycerine are added. The emulsion is sensitized by adding one-tenth of its volume of dye, and should be well shaken before coating the plates. The glass plates should receive a preliminary substratum of gelatine or india-rubber, so that the frilling of the film and impurities of the glass plates may be totally avoided.

* "Encyclopædie der Photographie," Heft 3, and Eder's "Jahrbuch," 1892, p. 387.

For small sized plates the emulsion is used somewhat thicker than for larger, and for the latter it should be diluted with alcohol and ether. After coating they should be dried at about 15° C., and then for some minutes exposed to a temperature of 30° C.

The plates should be developed with the following mixture:— 25 g. of sodium sulphite should be dissolved in 40 ccm. of warm water, then 10 g. of glycine added and 50 g. of potassium carbonate, at first in small quantities in consequence of the evolution of carbonic acid. When cool about 75 ccm. of a thin pasty liquid will be obtained, which may be kept as a stock solution, and before use must be well shaken and diluted with from 12-15 times the quantity of water. Wet plates should be washed before development, and the developer flowed on; dry plates should not be washed, and should be developed in a dish.

They should be fixed in sodium hyposulphite. The intensification may be effected with metol (see p. 39), and the blackening as described on p. 38.

Obviously the collodion emulsion may be used for ordinary work undyed.

The qualities of the cross-lined screen and the distance of the same from the sensitive plate will be described in Chapter V.

5. Preparation of Reversed Negatives.

For the different photo-lithographic work direct and reversed negatives are used; for the transfer process direct negatives are used; for printing direct on to the stone or plate, reversed negatives.

For making the latter various methods are used, the principal of which are as follows:—

(a.) Exposure through a Prism.

This method is, on account of its inconveniences and difficulties, only used when it cannot be possibly avoided.

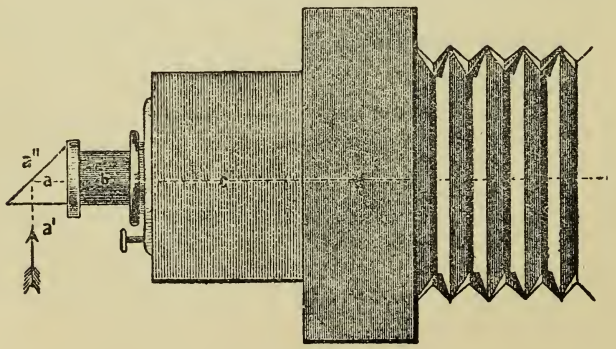

Fig. 5.

Fig. 5 shows the arrangement in which the prism *a* is placed in front of the lens *b*. The prism is three-cornered and the angle turned to the objective is a right angle. The hypothenuse is silvered. It is mounted in brass or nickel; on the mount is a screw, by means of which it is fastened to the objective, so that the side opposite to the hypothenuse lies upright to the side of the camera, and this position must be an exact right angle to the focussing screen. The camera itself must be absolutely horizontal. The subject to be taken, instead of being in front of the camera, is placed sideways to the prism. The image passes through a', falls on the silvered hypothenuse a'', from there through the objective *b*, through the box-shaped extension *c* and the camera *d*, on to the sensitive plate, which is not visible in the diagram. The exposure with the prism is about $\frac{1}{5}$th longer than usual, because a portion of the light is absorbed by the prism.

(B.) Placing the Plate the Wrong Way Round in the Slide.

Generally, for making reversed negatives of line drawings, it is quite sufficient to place the sensitive plate the wrong way round in the dark slide or in the carrier, so that the film side, instead of being towards the objective, is turned towards the operator. It is, of course, absolutely essential to use only glass plates which are absolutely clean and which contain no particles of sand, air bubbles, etc., which would show on the prepared negative as points. After sensitizing the plate, the back of it must be thoroughly cleaned, for any smudges or drops would be visible on the negative. Obviously great care should be taken also in cleaning the plate to make as little dust as possible. In the Imperial and State Printing Works nearly all the reversed negatives are prepared most satisfactorily in this way.

The photographic manipulations, the preparation, sensitizing and developing of the plates, etc., is exactly the same as with direct negatives.

(C.) Stripping Negatives.

There are various directions for making stripping negatives.

An india-rubber solution, consisting of equal parts of benzole and chloroform, in which an equal part by weight of india-rubber is dissolved, is used as a substratum. When the solution has become quite clear, the unreversed and unvarnished negative is coated with it. When the film is dry, a coating of raw collodion, to which some drops of castor oil have been added, is given. When this film is quite dry, it is cut through near the edges with a sharp knife, and the glass plate and film placed in a dish filled with water, when the negative film will loosen from the glass and after some time will swim in the water. In this operation the use of force must be avoided. The film is lifted from the water by placing a card

underneath it, carefully dried with fibre paper, then laid flat and pressed somewhat between tissue paper. The negative prepared in this way has many disadvantages. First of all, the film is easily injured, and, therefore, the edges should be bound with strips of paper in order to protect it from tearing; further, the film is easily folded and does not remain accurately of the same size, which makes it useless for certain purposes. Moreover, this process is somewhat costly. It is now almost entirely replaced by a process in which a gelatine substratum is used.

This process is as follows:—The unvarnished negative is accurately levelled with a level and coated 2 mm. thick with a solution of—

White gelatine...	20	parts by	weight.
Distilled water	500	„	„
Glycerine (chemically pure)...	25	„	„
Glacial acetic acid	10	„	„
Alcohol 36 %	50	„	„

The above quantity is quite sufficient for at least four negatives 21 × 26 cm. Many omit the acetic acid, but I have found that it is an advantage for the slow drying, the pliability, and the keeping of its size of the negative, to use acetic acid in moderate quantities. To a certain degree the addition of glycerine also effects this, but not sufficiently enough. Before pouring on the gelatine solution, the plate must be absolutely dry. Any air bells formed whilst coating must be pushed to the edge of the plate with a piece of card. The plate must be dried spontaneously in a room as airy and as free from dust as possible. In order to protect the film from dust particles, it is advisable to give it a paper cap or cardboard cover, which allows the access of air, and obviously it ought not to touch the film.

When the gelatine film has become thoroughly hard, it should be coated with negative varnish, and, after again drying, should be cut round the edges with a sharp knife right through to the glass and stripped from the plate.

If the glass was well-cleaned and prepared, as has been previously described on page 41, any gelatine film thus prepared will well and safely strip without a substratum.

With dirty or old plates, a substratum of a 1-2 % solution of india-rubber should be used.

After stripping, the gelatine films are best kept between filter-papers and under glass plates.

CHAPTER III.

PHOTO-LITHOGRAPHY BY THE TRANSFER OF A GREASY PRINT ON TO STONE OR ZINC.

1. The Home Preparation of Bichromated Gelatine Papers.

Photo-lithographic or gelatine papers are articles of commerce and entirely fulfil their purpose, and must before use be sensitized in a bichromate bath. In establishments where much photo-lithographic paper is not used, it is better to obtain it commercially from some reliable firm and not to make it oneself, as this is somewhat troublesome, and requires special appliances, some practice and experience, and with small consumption does not pay.

For those who are interested in the preparation of chromated gelatine paper I will now give the method, and I would remark that this paper possesses all the necessary qualities for this process.

A sheet of well-sized paper is soaked in a bath of cold water, or evenly damped with a clean pad, till it has become slimy. The water is allowed to drain off, and then the sheet of paper placed on a plate of glass which has been accurately levelled, and which rests on a levelling stand with screws, so that it can be easily levelled. By placing over it a sheet of blotting paper and squeegeeing with an india-rubber or flannel squeegee the air bells between the paper and glass are removed and any excess of water pressed out. Then the edges of the sheet are bent up to about the depth of 2 cm., and wood or iron rods laid outside, and a warm 1 : 30 gelatine solution poured on to it. A sheet 70 by 70 cm. will require 305 g., that is 7·5 g. of gelatine and 297·5 g. of water. The gelatine will set in a few minutes, when the sheet is removed from the glass and laid on a rack in a place free from dust to completely dry, and should remain from a day and a half to two days. Such gelatinized sheets can be kept in stock, and will keep fit for use in a cool, dry place for from six to eight months. For this purpose only good pure rag paper should be used, as the ordinary cheap papers contain many additions which render them unsuitable for this work.

(a.) The Gelatine.

The gelatine must possess certain qualities, of which the principal are as follows. Before all things it must be pure and free from grease, or else small round pits form on the surface, which give rise to troubles in developing and printing, and only produce

defective transfers. A large proportion of carbonic acid will produce the same faults, which may, however, be remedied by a small addition of ammonia shortly before use.

Gelatine is very hygroscopic, and therefore attracts moisture from the room where it is kept and dissolves completely in warm water. Even in very great dilution, *e.g.*, 1 : 100, it sets again to a jelly in the cold, but loses the setting power after being repeatedly warmed, or if the temperature was raised considerably higher than was necessary to melt it. Damp gelatine decomposes in the air very soon; the decomposition, however, can be delayed with salicylic and carbolic acids and glycerine. Greasy gelatine can be improved by the addition of 5 per cent. of alcohol. Too soft gelatine can be hardened with chrome alum, and one part of chrome alum may be used to 200 parts of gelatine, and by this addition the melting point is raised about 7°C. Too hard gelatine gives rise to the formation of bubbles. If the gelatine solution is slightly acid it is not a disadvantage.

The gelatine used in our establishment is of French make, and is known as "transparent white gelatine," and is also very suitable for collotype. I mention this because the gelatine frequently gives rise to failure. For practical work, then, it is advisable to stick to one make when it has been proved to be absolutely satisfactory.

To those who would study more closely this very important material for photo-lithography and collotype, I would strongly recommend the brochure "Ueber die Reactionen der Chromsäuren und der Chromate auf Gelatine, Gummi, Zucker und andere Substanzen organischen Ursprunges in ihrer Beziehung zur Chromatphotographie," by Professor Eder, in which the most exhaustive information on the application of these two materials so important in photography, gelatine and the chromate salts, is given in a concise, popular, and easily understood form.

(B.) The Chromate Salts.

The sensitiveness to light of the different chromium compounds forms at present the foundation of several photographic and photomechanical processes.

According to Dr. Eder, Vauquelin discovered in the year 1798 chromium and chromic acid, and made at the same time the observation that chromic acid formed with silver a carmine red salt, which became purple-red by the action of light. In the year 1832 the philosopher Dr. Gustav Suckow, in his work, "Die chemischen Wirkungen des Lichtes," stated that the chromate salts were also sensitive to light in the absence of silver if an organic substance was added, as in the light lower (green) oxidation products were formed. In 1839 Ponton added to Vauquelin's and Suckow's discoveries, and discovered the photographic application of chromate of silver, the light-sensitiveness of potassium bichromate on paper. The chromates are *per se* stable in light; in the

presence of organic substances, however, such as gelatine, albumen, gum, etc., a quick reduction of the same takes place in light. Talbot finally found that a mixture of gelatine and a chromate became brown in light, and lost at the same time its solubility in warm water and its power of swelling up in cold water. According to the same authority simple potassium chromate is from 20 to 25 times less sensitive to light than potassium bichromate, and the simple ammonium chromate shows the same sensitiveness to light as ammonium bichromate. For photo-lithography the latter salt, potassium bichromate, is very important, and it has the chemical formula of $K_2Cr_2O_7$.

(c.) The Gelatinizing.

The gelatinizing of the paper and the preparation of the gelatine solution is effected as follows:—

The gelatine, accurately weighed out, is placed in small pieces in the proper quantity of water, either in a large measure or some other vessel, and placed in a water bath and immediately heated. It is advisable to place the vessel containing the gelatine into the water bath before the latter is heated, so that both may heat together and fracture of the glass be thus avoided When the gelatine is completely dissolved the warm solution is filtered through a linen filter, and so that it may not be cooled the vessel into which the gelatine solution is filtered is also placed in the water bath.

Whilst still warm and liquid the gelatine is poured on to the previously prepared paper, and any bubbles of air brought to the edge of the sheet with a strip of stiff paper or a feather.

It should be especially noted the gelatine solution should be used up as quickly as possible or else it will deteriorate. Gelatine which remains for a long time in a state of solution becomes soft and fluid, and if the chromate bath is not well cooled a partial or complete dissolving of the same takes place in sensitizing or later in washing and developing.

(d.) Sensitizing.

The first thing to be treated of is the preparation of the bichromate bath. The necessary quantity of the bichromate of potash is rubbed up as fine as possible in a porcelain mortar with a little water; it should then be transferred to a larger flask and the necessary quantity of water added. When all the bichromate is dissolved the solution should be filtered, and so much ammonia added as will convert the orange yellow colour into a straw yellow. This bath can be kept, in a dark cool room, fit for use for a long time. The proportions for the solution are —

Potassium bichromate	1 part
Water	15 parts

and as much ammonia as will make it straw coloured. The bath is neutralized with ammonia or a soda or potassium salt, because solutions of the bichromate salts have the property of dissolving gelatine even in the cold.

The day before being used the sheet of gelatinized paper is placed in this bichromate bath, which should be as cold as possible; in summer it should be cooled with ice. It should be completely immersed in this bath, so that the solution covers every part of the sheet to the depth of 1-2 cm., and should be left in it about three minutes; care must be taken that no air bells form on the gelatine. If this should happen they should be removed with a soft brush, which ought not to be used for any other purpose. On the places not covered by the bichromate solution, which has been kept off by the air bells, the paper would not be sensitive to light.

For ordinary printing the paper may be dried in the air by placing it on a board, or better on a rack; for better class work, and actually for all work, it is better to squeegee the paper as soon as it is removed from the bichromate bath on a sheet of plate glass which has been well cleaned and polished with talc, the excess of solution or any air bubbles being removed by squeegeeing thoroughly under blotting-paper. Many operators slightly grease the glass plate. I have found that this is not necessary if a sufficiently cold sensitizing bath is used, the plate glass thoroughly cleaned and well rubbed with talc, and it is dried in an airy room. It is advisable to see that there is always ventilation in the drying room, and the more this is done the better the paper will behave in the subsequent operations.

To completely dry, the paper requires when drying by itself from three to four hours; from ten to twelve hours when squeegeed to glass. The best way is to sensitize the paper in the afternoon or the evening, so that it may be used the next day in the morning. The paper when sensitized will, when properly kept in a dark cool room, be in a fit state to use for several days. By squeegeeing on to the plate glass the paper takes a very high glossy surface, and thus in printing comes into intimate close contact with the negative. In exposing, therefore, every fine line appears with greater precision than on paper which has become wrinkled and uneven, and which has not been previously glazed. It should also be mentioned that this gloss is frequently obtained by burnishing the sensitized paper when dry.

(E.) The Printing.

After the paper has been sensitized and well dried it is printed.

The negative is first laid in the printing frame film side up. Then the paper is laid with the sensitive yellow side on the negative, and the frame closed. Before it is placed in the light, care

should be taken to see that the paper lies closely everywhere on the negative, otherwise it will in parts be indistinct, and the print be useless. For estimating the correct exposure a photometer should be used, and I take as an example Vogel's Fig. 6.

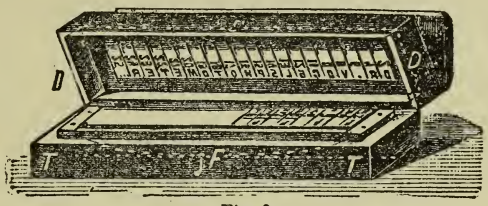

Fig. 6.

When beautiful clear negatives are used they should be printed to 14 to 16 degrees Vogel. Obviously no strict instructions can be given for every case, and it will be dependent on the quality of the negative and the object.

If the negative has to be covered, or any other dodge used, the time of exposure must of course be arranged accordingly. As a general guide it may be stated that the details of the picture should appear brown and distinct from the ground when the print has been correctly exposed. This examination of the picture must be done in a dark room, and only one side of the printing frame should be opened, so that the print does not shift. If it is over-printed, the picture develops badly, the lines become broader, the details disappear in the deep shadows, and the ink adheres to the unexposed parts. If, on the contrary, it is under-printed, the ink does not adhere well to the exposed places, and washes off in developing from the fine parts. Practice, as with all manipulations, is necessary, and therefore one must not be disheartened by the first failure.

(F.) The Inking Up and Developing.

As soon as one is satisfied that the exposure is sufficient, the print should be taken from the frame in the dark room. The next process is inking up and developing. This is effected in various ways; the ink is either spread on the dry print with a velvet roller or a thin developing ink is used with a brush, or the bichromate is first washed out and then the ink spread on. I prefer to ink up the print with a velvet roller, on which is the developing ink, before washing. By this method I obtain between ink and gelatine the soluble chromium film. The print develops then very quickly and well. For this purpose it is laid on a glass plate, a litho stone or any other flat surface, a small quantity of good litho transfer ink is distributed on an inking stone with an ordinary litho roller, and the velvet roller charged with the ink

from the stone by rolling it several times over the stone. The print is now rolled up with the velvet roller till it appears of a general grey tone; the details of the picture, however, are still visible through the ink. With this first inking up, too little rather than too much ink should be used. When the inking up is finished, the print should be laid in cold water, care being taken that no air bells form on the surface, and it is also advisable to frequently turn the paper over once or twice in the water. After ten or fifteen minutes a change will be seen on the print, the exposed parts will be somewhat more depressed than the unexposed, which will have swollen to some extent in the water. The print is now taken out of the water and spread out exposed side up on a sheet of glass, very carefully avoiding folds, and dried with blotting paper, and the water which is on the back of the print is removed by strong pressure on the print from the front.

The print whilst still damp is again for a second time rolled up with the velvet roller, by which means the details of the drawing again take the ink. From the unexposed parts the ink now goes on to the roller, in exactly the same way as in cleaning the litho stone, and they appear covered now with a very faint tone. If the first rolling up was done with too much ink, it will be accompanied by two disadvantages. Firstly, that too much ink will adhere to the details of the drawing, and there will be the danger that in transferring the same will appear thick, and secondly the tint will not be so well removed from the unprinted parts, which will produce a difficult development. It is therefore advantageous only to give in the second inking the printed parts the quantity of ink requisite for transfer.

After being inked up a second time the print is again placed for a short time in the water, then taken out, spread out on the sheet of glass, and now completely developed with a pad or a tuft of cotton wool. This is effected by going over all the print with light pressure and not too quickly with a circular movement, till the drawing appears quite clear and clean on a white ground. In this operation it is advisable to use as much water as possible, in order to remove all the bichromate from the print, which might be troublesome in the subsequent operations. The washing should not therefore be stopped till the unexposed parts have lost all yellow tinge and appear nearly white. If the bichromate remains in the unexposed parts, the process continues during the drying of the print; these places then become hardened, and are frequently the cause of an unsatisfactory transfer. *One of the chief requisites is, however, that too much ink should not be used in inking up. The developed drawing should not appear deep black, but grey, yet covered in all places.* The developing ink contains so large a quantity of grease that the least quantity is sufficient to form the combination previously described on the stone.

The developed print is freed from all adhering water by pressure with half-damp blotting-paper, and then fastened on to a board with drawing pins to completely dry.

The room where the development is carried on should be well ventilated, and not be heated too much, as the latter makes the work more difficult. The drying ought not to be forced and should be allowed to take place spontaneously at the ordinary temperature of the room.

For transfer to zinc and for sending photo-lithographic prints it is advisable to bathe them in a 10 per cent. solution of alum for about five minutes, so that the gelatine film is hardened. When the prints are to be used or to be transferred to stone immediately this treatment may be omitted without harm.

2. Various other Photo-lithographic Papers.

The paper described above is a pure gelatine paper, and although this has proved in practice to be satisfactory for all work that may arise, still I will describe some other papers, which have been also used in practice with good results, and for those who do not care to prepare their own paper they have the advantage that they may be obtained commercially.

Albumen was used first instead of gelatine and rendered sensitive by the addition of a chromium salt. This paper had the disadvantage that it could not be kept, and only sufficient paper and albumen solution for one day's work could be prepared. A much greater disadvantage, however, was that in developing, the albumen film was rubbed off with the pad, and the paper was more or less rubbed up. A tint was produced through this which transferred to the stone, and thus gave rise to considerable troublesome and tedious retouching. This is not the case, however, with the gelatine coating, which is comparatively more resistant.

(a.) Husnik's Photo-lithographic Paper.

Prof. Husnik has combined these two procesess for the production of his papers, as he gives a coating of albumen to a paper coated with gelatine, which should be rendered sensitive with ammonium bichromate. By this means is, on the one hand, the rubbing up of the paper prevented and damage to the image not easily possible; on the other hand, the development takes place very quickly, as the albumen film dissolves and can be easily removed with the greasy ink. Husnik specially contends that with the use of these papers he obtains extraordinarily sharp images without any tint. The sheets thus prepared will only keep, however, one or two days, and this inconvenient operation has to be repeated every time before using the paper. This applies also to the albumen solution, so Husnik has come to the conclusion that it is better and more practical to use plain gelatine paper; but

when trouble, time, and cost are not of such great consideration, then it is better to use the paper with the compound coating, as it enables less experienced operators to produce good work.

The paper more recently produced by Husnik is a pure gelatine paper, which is rendered sensitive to light in —

Ammonium bichromate	... ...	1 part
Water	... ...	15 parts
Alcohol (ordinary) ...	... ...	4 „

As much ammonia is added to the bichromate solution as will convert the reddish colour into yellow, and the bath smells of ammonia. The bathing of the paper must be done as quickly as possible, and the sheet should only be drawn through the solution. The exposure for this paper is from one to three minutes in the sun, or from ten to thirty minutes in diffused light.

The inking up of the print should be done with a greasy transfer ink, to which one-sixth part of wax has been added, and the whole dissolved in turpentine to the consistence of oil. The print is inked up with this thin ink, and then gone over with a pad of cotton wool till it has taken an even gray tint.

When the turpentine has evaporated the print is laid in cold water, and, after about ten minutes, developed with a soft thick pad with a continuous circular movement and quite light pressure. After development all adhering water is removed from the print with damp blotting-paper, and the transfer can be effected after from fifteen to twenty minutes.

Husnik, however, did not rest, and soon prepared a still better paper, which is known at the present time commercially as "Husnik's Autotypic Paper." He produces this paper in large quantities, the coating of the gelatine being effected by machines, which certainly tends to ensure equality.

Husnik found that by the use of less concentrated bichromate baths the fine lines were stronger after printing than from the nature of the negative they should be. From one and the same negative there was obtained by the use of a bichromate bath of 1 : 100 a relief five times as broad as when a bath of 1 : 15 was used to sensitize the paper. This he ascribes to the colour of the gelatine being less, so that more rays of light penetrated to the surface of the paper, from which it would be again reflected, and every point or line again reproduced, which must obviously lead to an increase of the size of the same; on the other hand, with strongly chromated paper, the rays of light would not only be absorbed by the intense yellow colour of the chromium salt, but still more by the brown tone formed immediately after printing, which makes a reflection impossible. With autotype negatives this is specially striking, as with weakly-chromated paper black shadows without details occur, because here the quantity of light is distributed by reflection over the fine points, and they will

therefore become thicker. When using strongly-chromated papers the details in the shadows appear open, clear, and sharp.

The concentration of the bichromate bath cannot be increased at will, because other disadvantages are produced, especially such a firm adherence of the greasy ink to the print that it transfers badly and a part of it always remains behind. The bichromate salt, when as strong as 1 : 18, dissolves the gelatine at ordinary temperatures, and the baths, neutralized with ammonia, have the disadvantage that the greasy ink adheres too little to the print and will be rubbed away in developing the drawing. In order to entirely obviate the reflection of the rays of light Husnik uses an addition to the gelatine besides a 1 : 22 acid bichromate bath, which produces a pure yellow tone in sensitizing the papers, is insoluble, and completely penetrates the film of gelatine, so that a reflection of the chemically active rays is entirely avoided.

This paper, which is also darker coloured, does not allow the light rays to pass through, and is specially suitable for the transfer of autotypes to stone or zinc.

For sensitizing this paper bichromate of potassium, sodium, or ammonium is used, but the sodium salt has acted the best.

In winter a 1 to 20 bath is best ; in summer, 1 : 22 or 1 : 24. The treatment of the paper, as well as of the print, is exactly the same as with other transfer papers. The bath will keep for fourteen days. Caustic ammonia ought not to be used.

(B.) Photo-lithographic Paper by Adalbert Franz.

A photo-lithographic paper, with which I have obtained very good results on stone as well as on zinc, with all kinds of drawings, is sold by A. Franz.

This is also a pure gelatine paper. But Franz adds to the gelatine solution manganese sulphate (this must not be confounded with manganese borate, siccative powder, which makes the transfer ink dry so quickly that a transfer to the stone or zinc is impossible).

Through the researches of MM. Lumière the manganese salts have gained considerably in importance, and they have been introduced into photo-mechanical processes. When an addition of about 10% of manganese sulphate is made to the acid bichromate baths for sensitizing photo-lithographic papers, the printed places assume a very much darker colour, which is an advantage in judging the print, in developing the finest lines, and points are retained much more easily than on paper sensitized with the addition of ammonia.

This paper possesses the advantage, which is also more important, that the—especially in summer—unpleasant ammonia bath need not be used. The paper is sensitized in a solution of—

Potassium bichromate	40-50 g.
Manganese sulphate	5 „
Water	1 litre

Ammonium bichromate ought not to be used. The bath would then become cloudy immediately, and both bath and paper made useless.

When sensitized the paper can be kept from eight to ten days without losing its good qualities.

With this a transfer ink is supplied in tubes, which must be mixed with an equal volume of turpentine and benzine, so that it becomes quite fluid. The print, when it is taken from the frame, is fastened on a board with drawing pins, and with a fine camel's hair brush coated with this fluid ink as evenly as possible, and just so much that a light grey tone is formed on the print. This paper must not be inked up with a roller. As soon as the turpentine and benzine have evaporated the print is laid in cold water, and after about ten minutes developed with a clean tuft of cotton wool. The print does not show a strong relief; the development takes place quickly and regularly. The ink, in spite of its being so thin, is very greasy, so that only a very light skin is necessary for the subsequent transfer. The tint produced by a negative slightly too thin cannot be easily removed.

The other operations are the same as for the other photo-lithographic papers.

Franz's photo-lithographic paper is characterized, as already mentioned, by giving extraordinarily sharp clean tranfers, which, indeed, may be due to the use of the very thin liquid greasy ink. It is, therefore, especially to be commended for very fine work.

(c.) Albert's Photo-lithographic Paper.

August Albert's is also a very good photo-lithographic paper. It can be obtained commercially in two qualities, viz., "Photo-lithographic paper" and "Autotypic high glaze paper." This has been tested in the K.K. Lehr-und Versuchsanstalt für Photographie und Reproductionsverfahren in Vienna, and has received a certificate of excellence. The high glaze paper has a prepared film of several coatings; the developed prints when dry keep the high glaze.

The sensitizing bath consists of—

Water	... 16 parts	by weight
Potassium bichromate	... 1 part	„
Alcohol (ordinary)	... 4 parts	„

and to this so much ammonia is added as will convert the reddish colour into a light yellow; a small excess of ammonia does no harm. The bichromate bath should not have a lower temperature than + 15° R, or else the solution cannot penetrate the film sufficiently, which results in a defective development. The duration of sensitizing is from four to eight minutes, till the paper is quite soft and damped through. It is preferable to sensitize too long rather than too short.

The paper should be squeegeed on to plate-glass, as already described, and allowed to dry spontaneously. The paper when stripped from the plate-glass shows a beautiful high glaze, and can be kept fit for use for twenty-four hours. When the paper is older it can still be used, but the development is more difficult, and it is better to avoid this for fine drawings or autotypes.

Albert does not recommend a photometer to be used when printing this paper, but by examination of the print to judge when this is correct. The image should have a brown tone, and be easily distinguished by the eye from the ground. Over-printing is disadvantageous, as the lines and points become broader, the prints develop badly, the tint adheres firmly to the ground, and the details in the deepest shadows are lost.

The inking and developing can be done by any of the known processes which is thought desirable. The chief thing is that too much ink must not be used in the first inking up; any intensification required may be effected with a second coating. This is, especially for fine drawings and autotypes, very important, whilst for coarser work also once inking is sufficient. The prints are then placed in cold water, and after sufficient washing should be developed with a soft pad or pad of wool, with which any tint can be very easily removed from any parts which should remain white.

3. The Photo-lithographic Transfer.

(a) Treatment of the Photo-lithographic Print and the Plate.

The transfer from the bichromated gelatine paper requires generally, as regards treatment and choice of the material, greater care on the part of the printer than an ordinary transfer, and this increases in transferring fine drawings or autotypes on to stone.

In the first place the good quality of the stone should be looked to. For ordinary or coarsely drawn subjects this is of less importance, but for fine drawings and autotypes it is of the highest importance. Further, accuracy and cleanliness are all important, without which successful work is impossible. On the other hand, a transfer can hardly fail if it be accurately and correctly performed.

When the print comes from the developing bath, and has been well washed so that every trace of bichromate is removed, it should be freed from excess of water between blotting-paper. It should then be dried in a not too warm place free from dust till the gelatine has completely set and feels absolutely dry. The relief will have now again disappeared, and the black and white places lie in the same plane. It is best dried by pinning it to a board with drawing pins, and then set up in a dry place.

In the meanwhile the transfer stone should be prepared, which must be absolutely faultless. Just before the transfer it should be dry polished with pumice stone, and then well dusted with a

cloth. The slightest grain will give a spot in a fine tone. Obviously the stone must be well ground so that neither any spots nor lines of an earlier transfer can appear. With an open drawing this can be corrected, but not with an autotype; in such a case the shortest way is to make a new print and a new transfer.

The print is first wiped over on the back with a damp cloth, and then laid on damp blotting-paper. After about five minutes the print is treated a second time with a damp cloth, and then laid between damp blotting-paper. It is not advisable to lay the print between ordinary damp blotting-paper, as the gelatine becomes somewhat sticky, and would attract particles from the rough paper.

The degree of dampness which is necessary for transfer may be judged in that the print must feel soft, but the gelatine film ought not to be very sticky. Any further preparation of the print before transferring to the stone is not necessary. The print is laid on the stone, over it a dry sheet, and then the cover, and then drawn through the first time with light pressure.

In order to prove whether the transfer has taken well a corner may be lifted up. All the ink which was on the print must be transferred to the stone, and then the transfer has been completed in the correct way. The print is now pulled off the stone and the transfer made ready, like any other.

With this method of treatment the print will strip easily, which is not the case if it was not well dried after the developing bath; a much sharper and cleaner transfer will also ensue. If the print was too damp a fuzzy, broken-down transfer will be obtained, because the gelatine, which has become too soft, will be broken down.

I will also mention that it is not advisable to treat fine drawings or autotypes with the rubbing-up pad. It is better to go over the transfer with the roller, and the tones are kept cleaner. The stone is then gummed, placed on one side, and allowed to stand some hours before being etched.

For transferring to zinc plates which are to be etched or to be printed from, the bichromated gelatine print should be bathed in a ten per cent. solution of alum, allowed to dry, and then, as previously described, damped, and then transferred under the same conditions as to stone.

It only remains to mention that the stone or zinc plate should not be too cold.

(B.) Failures in the Photo-lithographic Transfers.

The failures or faults which are met with in photo-lithographic transfer may be caused by various things.

The squashing down rarely happens with photo-litho transfer, because a good photo-lithographic paper will bear a considerable

amount of dampness. When, however, it occurs it may be assumed that either too strong pressure or insufficient care in the setting of the stone is the cause. Much more frequently it happens that some parts of the print do not transfer at all, or only in a defective manner. The chief reason of this is that the print was insufficiently damped. This frequently happens if ordinary or gravure prints are to be transferred with photo-lithographic prints. If the printer encloses the impression on the ordinary transfer paper and the photo-lithographic together in the same damp sheet, and if he estimates the degree of dampness from the gravure print, the photo-litho paper will be insufficiently damped and a good transfer will not be obtained from the latter. If, however, he waits till the photo-litho paper is damp enough, the other impressions will be too damp and will squash out in transfer. For such work the print on ordinary transfer paper and the photo-lithographic print should be kept separate, so that the different dampness requisite for each can be regulated.

Another case which frequently happens is that the print is contaminated with particles of dust or other foreign substances. These may be flying about in the air or be on the stone, the roller, or the damping paper. Through this many transfers of fine drawings are rendered useless. Perfect cleanliness of the utensils and the use of the correct ones, combined with a drying-room for the print absolutely free from dust, are absolutely essential for faultless work.

The composition of the ink, especially if it was too hard, may give rise to bad transfers.

Photo-lithographic papers, which are prepared with very hard gelatine, must be laid before transferring in lukewarm water. By this means the hard gelatine becomes rather sticky, and the greasy ink transfers much better. Even those points which in developing have taken up little ink, and appear grey, transfer completely to the stone and adhere firmly.

CHAPTER IV.

PHOTO-LITHOGRAPHY BY DIRECT PRINTING ON TO STONE OR ZINC.

The processes of photo-lithography previously described are based upon the printing on to bichromated gelatine or albumen paper development with a greasy ink and subsequent transference of the greasy print to plate or stone. A process may also be used in which the stone or plate is printed on direct. There are in this various methods, of which the principal are printing on to light-sensitive asphalt, or an organic substance, gelatine or albumen, in combination with a bichromate salt. The reason is the high sensitiveness, which is possible, of the substances used.

1. THE ASPHALT PROCESS.

(a.) The Light-Sensitive Asphalt.

Light-sensitive, or so-called Syrian, asphalt, which is prepared for photo-lithographic and photo-zincographic purposes, can be obtained from various firms who deal in photographic goods, and one has only to dissolve the same according to the prescribed directions. This kind of asphalt is, however, not very sensitive, and in use must be printed for some considerable time. If, therefore, an asphalt of greater sensitiveness is desired it is not sufficient to merely dissolve Syrian asphalt, but it must undergo a preliminary preparation.

Only that part of the asphalt is sensitive or useable for photo-lithographic work which does not dissolve in ether. The insensitive part must, therefore, be separated out, which is done by finely powdering the asphalt, sifting it through a fine sieve, and then treating it with ether. All that is soluble in ether goes into solution ; the marc which is not soluble in ether is then dissolved in benzole and used as wanted.

(*a.*) Husnik's Process.

Professor Husnik has improved this process in so far that he does not dissolve the asphalt powder in ether, as, according to his view, a complete solution of all the insensitive portion is not attained by this process, but he dissolves coarse asphalt powder completely in rectified spirit of turpentine to the consistence of a moderately-thick syrupy mass, until no hard particles or a residue are contained in the solution. To this viscous asphalt solution a plentiful quantity of ether is added gradually, and with constant stirring, and a big flask should be used for this purpose. After a sufficient quantity of ether has been added a pitch-like deposit

separates out at the bottom. In order to test whether there is still any light-sensitive asphalt in the supernatant liquor a small quantity is poured into a glass and mixed with ether, when if a precipitate ensues more ether must be added to the big flask.

After standing for about twenty-four hours the ether contains all soluble insensitive constituents of the asphalt; the pitch-like residue in the flask, after pouring off the solution, is again treated with ether, so that all turpentine is extracted and any stray insensitive particles are dissolved. The pitchy residue is now removed from the flask and allowed to stand in a porcelain dish in a warm place, with frequent stirring, till it is quite freed from ether, and has formed a hard, brittle, black shining substance, which can be easily broken up into powder with the hand. This product is now the light-sensitive asphalt, which is dissolved for use in anhydrous benzole. As benzole is only to be obtained anhydrous with difficulty, some chloroform is added to the solution in order to prevent the running together in drying, whence the film would become unequal and patchy.

The coating of the stone or plate with the asphalt film is very simple; it should be placed horizontal, and then whirled rapidly on a whirler.

Printing under a clear negative takes from a quarter to half an hour in direct sunlight.

The picture is developed with turpentine.

(*b.*) Valenta's Process.

Valenta recommends for photo-lithography asphalt which has been sulphurized by the wet process, as it possesses a considerably higher light-sensitiveness than that which is not sulphurized.*

The process is as follows:—100 g. of raw Syrian asphalt are boiled in a retort with an equal quantity of raw pseudo-cumene, which has the formula $C_6H_3(CH_3)3$, and a boiling-point of about 170°C., with 12 g. of flowers of sulphur, which should have been previously dissolved in the pseudo-cumene. When after about three or four hours' boiling the evolution of sulphuretted hydrogen has ceased, the pseudo-cumene is distilled off and the black pitchy residue dissolved in benzole in the proportion of 4:100, and used for the preparation of the plate or stone.

The sulphurized asphalt prepared in this way is almost insoluble in ether, but dissolves fairly readily in benzole, toluene, xylene, cumene, and turpentine, and is very sensitive to light.

With this asphalt good prints are obtained even in bad, cloudy weather. For use four parts of the sulphurized asphalt are dissolved in 100 parts of benzole, the solution filtered and diluted till a thin film on a zinc plate shows a golden yellow colour. Exposure of the asphalt solution in an open flask for from half to one hour in sunlight is advisable.

For developing the asphalt image rectified oil of turpentine free

* Eder's "Jahrbuch der Photographie," 1892, p. 241.

from acid is used; the best is French or Austrian. The development may be accelerated by adding Hungarian or Russian turpentine, which, however, attack the asphalt image; it can be restrained by the addition of ligroin, benzine, or wood oil to the turpentine.

Zinc plates are best developed in a dish, stones by making a wax margin round the drawing. The oil of turpentine is poured on and rocked to and fro. Rubbing with a pad of cotton wool, etc., should be avoided. After development the plate should be well washed under a stream of water, and before gumming, the plates should be exposed for some time to light, as this makes the ground more resistant to the etching.

(B.) Coating the Stones.

The stone or zinc plate is now coated with one of the above-described asphalt solutions, or with the following:—

Asphalt	20 g.
Chloroform	300 „
Benzole	100 „
Oil of Lavender	20 drops.

The solution must be thin, so that it flows over the stone well and does not form unequally-covered patches.

The subsequent manipulations must be conducted in the dark.

The stone which is to be used must be well ground, and polished with dry pumice stone, well dusted, and be absolutely flat. It ought not to have any depressions, as the negative would not lie in contact there. The places would not print sharp, and therefore a bad result would be obtained.

The necessary quantity of the solution is now poured into the middle of a well-polished stone, and distributed as evenly as possible by rocking backwards and forwards. When thoroughly distributed the stone should be placed on the whirler and kept for some time in motion. The asphalt solution must be as thin as possible, so that it appears yellowish-brown and the colour of the stone appears through it. If the stone is only covered all over the film can be very thin; on the other hand, if it is too thick it will not print through, and will develop badly, as too much of the asphalt will dissolve. If zinc plates are used for printing they should be prepared as previously described on p. 6. Zinc plates for deep etching must be well ground and well polished, and ought not to repel water. The zinc plates are coated the same as the stone.

(C.) Printing.

When the film is absolutely dry, which will be in about fifteen minutes, printing may be proceeded with. For this purpose the negative is either laid on to the asphalted stone, film side down, and pressed down with screw bands, or it is laid, the glass downwards, in a specially-constructed and very strongly-built printing frame, which is provided with a sheet of plate glass, and the

asphalted side of the stone laid on this, the printing frame closed, and then exposed to light. The exposure continues according to the strength of the light and the nature of the negative from 15 minutes to 1½ hours. If the film of asphalt be thin and the negative clear it may be printed to 18 or 20 degrees in Vogel's photometer. This kind of printing always requires some experience, as various factors, such as the thickness of the asphalt film, the density of the negative, also the fineness of the drawing, have to be taken into account. It will be understood that the asphalt film must always be coated as evenly as possible.

If it is printed too long the stone will not develop at all, or only in parts; if it is printed too little the drawing wholly or partially dissolves In both cases an unsatisfactory result will be obtained. Negatives very clear in the lines of the drawing, and well covered in the ground, are here more essential for success than with the chrome gelatine process.

(D.) Developing and Inking Up.

When properly printed the frame and the stone should be brought into the dark room and development proceeded with. For ordinary Syrian asphalt rectified turpentine can be used, and one of two methods may be adopted. The stone is laid in a pan as straight as possible, and then flowed over with turpentine, which should be allowed to remain on it for some time, and then poured off into the pan. Fresh turpentine is now applied till the drawing appears clear and distinct. The turpentine which is allowed to run off can be used for washing purposes. An edging of warm gutta-percha may also be made round the drawing, and then turpentine poured on to it and the stone rocked up and down till the drawing is developed.

The very sensitive kinds of asphalt of Husnik and Valenta are much more readily soluble than the ordinary Syrian asphalt. In developing one must go carefully to work, and not allow the turpentine to stay on the stone a long time, but to pour it over the stone, which should be inclined so that it can run off. This can be repeated if required. It can be well and safely developed if half and half of turpentine and linseed oil is used, which, however, has the disadvantage that the stone becomes greasy, but this can be taken off by the expert printer.

After developing the stone should be well washed under a strong stream of water, then allowed to dry in the light, as by this the asphalt film becomes more capable of standing the etching, and then be coated with neutral or very slightly acidulated gum. After gumming, the stone is again dried and allowed to stand for some hours to rest, after which it can be inked up and etched, and finally sharp etched.

The zinc plate is, after development, also well washed, then allowed to dry, treated with thin gum solution, then with an

etching solution of tincture of galls or gallic acid and phosphoric acid, and inked up.

Prints on zinc plates for deep etching are gummed after developing, and if the asphalt film is perfect without rubbing up with a pad, which thickens the drawing, etched for some minutes in very dilute nitric acid.

Many lithographers are accustomed, and indeed it is necessary with some transfers, to rub the prints up with greasy ink. The process is as follows:—Greasy transfer ink is diluted with some turpentine, and after the stone has been gummed and allowed to dry, then washed, the drawing is wiped over with a soft pad with this dilute ink, when the ink adheres to the drawing, strengthens it, and if great care is not taken, thickens it also. With asphalt prints this is absolutely useless, and for other direct prints, as well also as for good chromated gelatine prints, in most cases unnecessary. The exposed asphalt combines so intimately with the stone that strengthening with a greasy ink is quite unnecessary, is indeed absolutely purposeless, as the ink can neither penetrate the hard asphalt film nor combine with it. The film of asphalt alone is so resistant to every etching solution that it is for this reason absolutely useless to strengthen it.

2. OTHER PROCESSES.

Besides the asphalt other mixtures of other light-sensitive substances may be used for direct printing, and these are mostly organic substances in combination with a chromium salt, and possess also a greater sensitiveness to light than asphalt.

The solutions which have been specially used in our establishment consist of —

(A).	Albumen	5 g.
	Ammonium bichromate ...	3 „
	Distilled water	500 „
	Ammonia	15-20 drops
(B).	Chloroform	250 g.
	Benzine	50 „
	Alcohol	20 „
	Mastic	2 „
	Aniline red	2 „

Solution A is strongly sensitive to light, and is used for coating the stone or zinc plate; with solution B the stone is coated before developing. The details of the process are as follows:—

(A.) Coating the Plates.

After the stone has been carefully polished and well dusted it should be first flowed over with distilled water, in order to increase the possibility of spreading the sensitive solution. When the water has run off, the stone whilst still damp should be flowed over with solution A, and care should be taken that the same is evenly distributed and that no bubbles form. The stone should be

placed immediately on the whirler and rotated till the solution is dry. Obviously a thick film must be avoided, as in such a case the print would not adhere to the stone.

If a zinc plate be used it must be well prepared and be rendered free from grease. To prove this the plate is flowed over with distilled water, and when this spreads equally all over and is not repelled from any part, the solution can be poured on. If, however, the plate does not willingly take water everywhere, it must be again cleaned or polished. The other operations are the same as for the stone.

(B.) The Printing.

When the film is quite dry, printing may be proceeded with. The duration of printing depends obviously also here again on two important factors—the quality of the negative and the strength of the light. Under a good negative with absolute bare glass in the lines of the drawing I print to about 10° Vogel, for example:—

In direct sunlight (middle of April, 11 a.m.) ...	2 min.
In the shade „ „ „	5 „
In electric arc light (3000 c.p., at a distance of 50 cm. = 20 ins. without reflector) ...	25 „

The picture is faintly visible. If the negative was too thin, or if it be over-printed, the image develops badly or not at all. With under-printing the film washes right away.

Immediately after printing the stone or plate is coated with solution B, which is distributed as evenly as possible by rocking backwards and forwards. It is not necessary, however, to obtain even distribution with a whirler. The whole of the coated surface becomes deep violet.

(C.) The Development.

When solution B has become completely dry, the stone is placed in a suitable vessel with pure water. After about five minutes the places not affected by light dissolve if the stone is rocked, and it is only necessary to go over the drawing with a pad of cotton wool to clean the same completely. The drawing now appears a deep violet on a bright ground. The development is continued without rubbing strongly with the pad—which might rub up the drawing—till all the details of the drawing appear clear and distinct. This especially applies to the details in the deep shadows.

(D.) Further Manipulations.

When the stone or plate is correctly developed, which can be easily told, it should be well rinsed and again exposed to make the film adhere firmly. It should then be gummed and treated as previously described in the asphalt process. The "rubbing up" of the stone or plate is not necessary; it is better to roll up the drawing with an ink roller. Zinc plates for deep etching can be lightly etched, then dusted with fine asphalt of resin powder, heated and then further etched.

R. J. Sachers, of Toronto, Canada, published a sensitive solution which has the following composition:—

Distilled water	150 parts
Fish glue	50 „
Ammonium bichromate	2 „
Ammonia	2 „
Chromic acid	1 part

This solution is brown, not very transparent, with an olive green tinge, and must stand and settle at least twelve hours before it can be decanted, filtered, and used. The time of exposure is about—

Direct sunlight	2-5 minutes
Diffused light	12-15 „
Electric arc light (3000 c.p., 50 cm.)	30 „

The image appears a bright brown on the golden yellow ground of the plate. The development is effected in an aqueous solution of methyl violet, when the image assumes a beautiful blue violet colour. The developed image is hardened with alcohol. The results by this method are very good, and although this is recommended for half-tone etching, it is also suitable for photo-lithography.

Excellent results also attend the sensitive "Marine glue solution," prepared by A. Hebensperger, of Munich, to which a second solution called "Chlorogutt-losung" is added. The sensitiveness to light is very high, and the treatment about the same as with the first described substance. The "marine glue solution" consists of albumen, bichromate of soda and ammonia. The dye solution of Victoria blue dissolved in benzine.

The process published by Waterhouse consists of coating a prepared zinc plate with a thin chromated solution, and then drying in a few minutes with a gentle heat—

(A.)	Arrowroot	2 parts
	Potassium bichromate ...	9 „
	Water	700 „
(B.)	Alum	1 part
	Water	1 „

For use mix—

Solution A	40 parts
Potassium bichromate... ...	5 „
Solution B	15 „

This is printed under a reversed negative for about six minutes in the sun. The plate is then laid for about half an hour in cold water in order to remove the chromium salts, and then cleansed from all soluble parts with a pad, and after well washing set up to dry. It is then inked up with transfer ink, and after about fifteen minutes washed with turpentine. This process, as, indeed, all direct printing processes, offers many advantages for preparing colour plates from a coloured object with one negative. The register of the separate plates is very exact, which is not always the case with a transfer process. In reproducing line drawings the unnecessary parts on the stone or plate can be covered.

CHAPTER V.

THE HALF-TONE PROCESS FOR PHOTO-LITHOGRAPHY.

The half-tone process is used in photo-lithography to reproduce originals which do not contain distinct lines or points, but closed tones, which are executed either in one or several colours With this process any coloured picture, oil, water, pastel, indian-ink or sepia drawing, as well as any photographs from nature of living, moving scenes, or still life objects can be prepared for reproduction on the printing press.

I will first describe briefly the theory of the process, and then come to the practical part.

As regards the photographic part and the quality of the negatives, in the present state of this method of reproduction the same principles apply as in line reproduction; where they differ I will mention the same.

The duration of printing, the transfer of the image to the stone, as well as the other arrangements will be described in the different processes.

We divide this chapter again into two sections:

1. Methods in which the half-tone is broken up when making the negative.

2. Those methods in which the formation of the grain is effected after the negative has been made by some suitable means.

1. Breaking up the Half-Tone on the Negative (Autotypy).

Of the various methods by which a breaking-up of the half-tones can be obtained, the so-called "autotypy" is the one most used practically. With this process the half-tones are broken up in the negative.

As every important technical discovery is formed not at once, but must be made by a longer or shorter series of smaller discoveries or improvements in order to attain the hoped-for goal, so was it also with autotypy.

From the work of Paul Pretsch, Mariot, Brown, and Fred. E. Ives the present state of the certain and beautifully-working half-tone process gradually evolved, and the last process, which ought to be considered as the immediate predecessor, is far outshone by autotypy as now practised.

Early attempts were made to obtain a printable image on stone by breaking up the chromated gelatine film, so that an irregular so-called serpentine grain was formed on it, which corresponded

fairly well with the theory of lithography, but gave no precise lines and no beautiful gradations of stone. If the grain was somewhat too coarse the effect of the picture was lost, the tone gradations were too far apart, and only light and shadows were given; if the grain was too fine the stone was not printable.

A further experiment was printing a design over the original, the strength of which had to be brought in correct proportion to the original; the impressing of a design was also tried, and when using this method the correct angle of the incident light when making the exposure had to be taken into account.

Further experiments, which were principally carried out by Mariot, Cronenberg, and others, were founded principally on the basis of breaking up the tones in printing. For this a lineature or screen on glass, or a gelatine film, was introduced between the negative and the sensitive film. Others, again, coated the blank glass plate with a lineature, and prepared the plate afterwards with collodion or gelatine emulsion for the exposure.

It will be thus seen how this method of reproduction developed step by step till net-work of silk muslin or woven horsehair, and finally grating images, strongly reduced by photography, were placed in front of the photographic plate.

Thus were efforts made to make half-tone pictures suitable for printing by litho- or typography, and although the end was very nearly attained, yet the crux was not quite solved. These methods did not, however, yield the desired result, namely, a beautiful sharp clear image. There was still required a considerable improvement of the existing methods, and this was made by Meisenbach, of Munich.

The principle by which Meisenbach prepared his images was essentially different from the previously-described results. He broke up the half-tones, also by means of a lineature, into a printable grain, but the process was essentially different from the previous methods, in that Meisenbach used a glass plate on which, on a black ground, a grating was drawn till the glass was laid bare, and in this way prepared a lineature which consisted of clear glass transparent lines and absolutely opaque lines.

He produced, first, an ordinary negative, from this a positive, and from this, by the interposition of the lineature, the actual half-tone negative for making the printing plate. The lineature or screen was in the second exposure interposed before the sensitive plate, and half the time of exposure given; then the screen was turned till the line first obtained crossed the second at an angle of 90°, and then the exposure was completed. By this means an absolutely certain breaking up of the half-tones into mathematically exact points was attained, and the most important step made in making photography useful for preparing printing plates for the two principal methods, typographic and lithographic. Meisenbach has called his process "autotypy." It was, indeed,

somewhat inconvenient, but had the advantage that on the negative and also on the positive any retouching that was necessary could be done.

I cannot here enter into the numerous simplifications and improvements of Meisenbach's process which, as well in the photographic process as also in the preparation of the lineature, were in the course of time made partly by him and partly by Carl Angerer, Gillot, Bussod and Valadon, Lefmann, and others, since, on the one hand, it would carry us too far, and, on the other hand, they may be considered as a natural consequence of the discovery. I will only mention that it was found after a short time that the two exposures and the production of the necessary positive could be omitted, and that the lineature could be simply interposed before the sensitive plate in the first exposure, by which an important simplification of the work was attained, and, thanks to the continued perfecting of the processes, no detraction of the good results was thus produced.

I do not consider it superfluous to give a short explanation of the action of the interposed lineature on the photographic plate during exposure.

If we take, for the sake of simplicity, not a picture, but a scale with four or five-tone gradations from light to deep black, the light tones will act more or less on the sensitive photographic plate according to their degree of brightness, but as the rays of light have to pass through the cross-lined screen interposed between the lens and sensitive plate, and as the rays can only pass through the transparent parts and not through the opaque, no homogeneous surface is obtained on the negative, but a tone produced by the cross-lines of the screen. If the tone was very bright, the rays reflected with great intensity on the sensitive will completely decompose the silver film. Since they are prevented by the screen from acting with equal power on all places of the surface, these places will show very plainly on the negative, and the result is therefore a darker tone on the same, which is marked with bright fine lines, corresponding in thickness to the screen plate.

If the original tone was darker so many rays of light will not be reflected, and these have thus not the power to impress the screen on the sensitive plate in full intensity; the result is therefore on the negative a tone which does not contain such strong dark lines as the first; the tone appears lighter in the negative, and in the print from the same darker than the first.

In the reproduction of deep black surfaces finally no rays of light are reflected, therefore no rays of light can penetrate through the screen, and because actually here no chemical change of the light sensitive film takes place, we obtain a negative which is clear and transparent in these places, that is to say without any interruption, which gives in the print a full black tone.

In this process there comes, however, to our aid a very important physical law, namely, the diffraction of light. A ray of light passing through a round hole or a slit and falling on to a black surface is represented not the same size as the slit, but more or less broadened the more the receiving surface is moved away, and in the middle the brightest light will be, and this gradually fades off into shadow towards the margin.

If we take now the opposite, and use instead of the hole or slit a black surface or a conglomerate of such in the form of points, squares, or other geometrical figures, and if these be placed before a screen illuminated with a bright light, these figures become somewhat smaller with this bright illumination, whilst with a weaker illumination they are represented in correct strength.

Where the light acts in its full intensity, or in excess, in a manner of speaking it is diffracted or bent over the figures, and proportionately makes them smaller.

This law does good service in autotypic work.

As we have seen, the rays of light must pass through the screen during exposure. This screen consists of equally thick opaque black and transparent white lines. Where the light acts with full intensity it will be more diffracted over the black lines. It makes the lines of the screen broader on the negative, and will, therefore, have more covered places, which in the after printing of the prints cannot be penetrated by the light, and thus represent the light places in the print covered with fine dots.

The darker the tone the less the rays of light reflected, and the less, therefore, can the light be diffracted. As the tones get darker the lines of the screen become of equal value on the negative, till finally, when at the opposite end of the screen, they totally disappear in the deep blacks.

A valuable quality of a correctly-prepared autotype is, therefore, that the covered lines or the covered grain appear of different strengths on the negative. In the high lights they are stronger, in the half-tones weaker, till finally in the black parts they have totally disappeared.

A further not less valuable property is that the grain in the highest lights is not sharply defined, does not appear as a square point, but is rounded by the diffraction of light, which gives a softer, more beautiful appearance and plasticity.

Whilst the light reflected from the brightest parts of the drawing acts with full intensity, and is diffracted over the figures standing in its path and makes the same smaller, and cuts off the sharp corners and gives more covered surfaces to the negative, as it decreases according to the more or less deep shadows of the drawing, and can only act now with less intensity through the open places of the screen, the result is that the points become larger, till finally in the deepest parts it is quite inactive, and the shadows begin to block. The action of the light rays of different

strengths reflected on to the negative in accordance with the brighter and darker tones of the drawing, taking into consideration the print, can be graphically represented as a pyramid of which the base represents the deepest shadows and the point the high lights. If we interpose a cross-lined screen, or more correctly called a grain plate, before the sensitive plate, we obtain, graphically considered, grain figures, actually of many more very different sizes, as shown in Fig. 7, 1-6, in which the smallest points represent the high lights of the drawing, and those becoming gradually bigger the gradually increasing shadows.

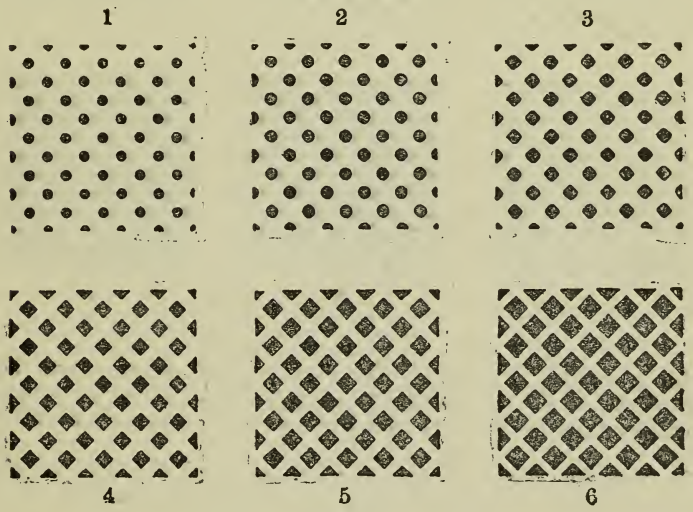

Fig. 7.

The original grain plate contained, measured diagonally, five black points, five white interstices to the millimetre. The figures represent enlargements of a negative made with the above-named grain plate, and for this the grain plate was one millimetre distant from the sensitive plate.

The accompanying Figure 8, 1-6, represents very much enlarged the scheme of grain of an autotype from a perfectly-executed wash drawing, with a screen of five opaque and five transparent lines to the millimetre, in equal proportions of black and white, at a distance of one millimetre from the sensitive plate, with equal time of exposure before and after the turning of the screen, and obviously with correct exposure for the whole.

The scheme is only given here in six gradations of tone. As a matter of fact, a good autotype has at least from six to eight times the number of tones, as with a sharp screen and an original cleanly

and sharply drawn in many tones, the light reflects the least alteration of tone in the size of the grain.

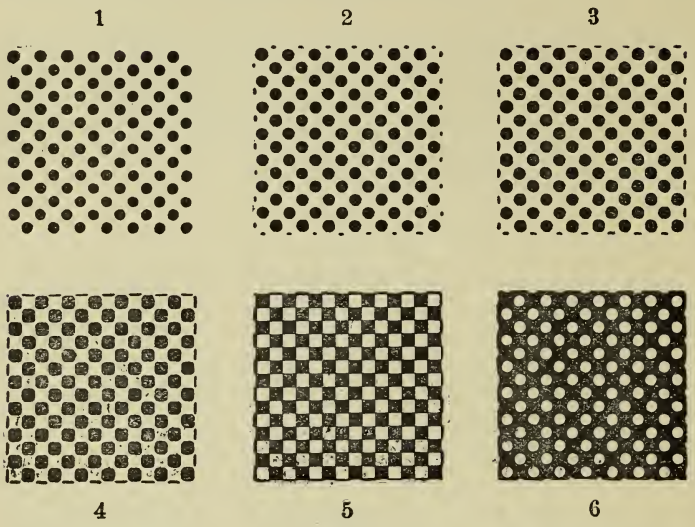

Fig. 8.

As previously mentioned, the smallest points represent the highest lights of the drawing; the larger, according to our graphic representation, the darker tones, but a correct reproduction of the grain.

In a similar way obviously the formation of the lines on the negative behave with an interposed but not revolved screen. Here also the lines in the high lights of the negative appear more covered than in the shadows.

The proportion of grain can, if the original requires it, be so far altered by not giving equal exposures for each position of the screen—for instance, in the proportion of two to one or three to one. We obtain then on the given scheme less closed tone gradations, 3, 4, and 5, and just before 3, and between and after 5, tone gradations, no single black and white points, but more or less jagged black or white lines, whilst the open black grain in 1 and 2 becomes more an oval instead of the round form in 6, and beyond the round openings are drawn out into ovals.

We have, however, in autotypy still the physical law, which is very useful to us, and that is the greater or less distance of the point from the light surface. The nearer a point or a figure is brought to the wall on which it should throw the shadow, the greater the size of the original, and so much sharper will be the outlines of the shadows. The more the point or the figure is

removed from the wall the less the shadow will correspond to the shape of the original; it will be smaller and less defined. The shape will also frequently change, and a square will become a round. We have then in the near or distant position of the lineature to the sensitive plate, on which it throws its shadow, an important assistance to act on the general tone gradations of the image. Let us remember that in focussing the shadow-forming object on to the surface on which the light falls, we obtain the same formed in all its actuality on the receiving surface; therefore, when this refers to a lineature with equal proportions of black and white, we obtain these in equal ratio. When, however, we remove the lineature from the light-receiving surface, the shadows which it throws contract, the lights predominate, we obtain no longer the ratio of 1 : 1 between light and shadow, but about 1·5 : 1 and so on.

By placing the lineature close to the sensitive plate, we obtain more closed tones, and as this gradation of tone is carried naturally throughout the whole of the image, also less high lights, less deep, middle shadows, whilst the deep shadows appear in their natural strength. With the removal of the lineature from the sensitive plate, on the other hand, the ratio of tones for the whole image, as well as for the details, is displaced. In the first place we shall obtain a picture which contains more contrasts of black and white. The light tones become considerably lighter by the reduction of the shadows. The dark parts, on the other hand, attain full vigour. In the first place, therefore, the original has to be considered as regards the distance of the lineature from the sensitive plate. Obviously, therefore, no accurate directions can be given in a case where feeling and experience are required. Next to the original, the number of the lines on the screen has to be considered. As a rule, one uses lineatures with five or six transparent and opaque lines to the millimetre (= 125-150 to the inch), and for these a distance of $\frac{1}{2}$ to 1 mm. (= $_1\frac{1}{2}$-$_2\frac{1}{5}$th inch) from the sensitive plate is generally sufficient for most cases. With a less number of lines the distance can be increased.

Autotypy is a process in which unprintable half-tones can be broken up by the use of a well-defined physical law into a mathematically determined grain, and the size of the grain can also be regulated to a certain extent with certain precautions.

It is, therefore, easily understood that the autotypic process is now very general and most used, and not only in the limited department of photo-lithography, but in a more extended way, does excellent service for the preparation of illustrations of all kinds, for the simplest picture for the daily paper as for the finely-printed magazines and journals, for simple monochromatic printing, and for the highest colour printing.

With accurate knowledge and command of the technique of

photography and lithography, there is required before everything, for successful work, a faultless screen plate. The indispensable requirements which must be found in the screen are absolutely opaque black lines and bare glass in the white lines. The home preparation of such a screen plate is a somewhat difficult matter, and will not be absolutely successful if one has not a faultless ruling machine, a composition which is thoroughly opaque, which adheres well to the glass and gives clean, sharp lines in ruling, and which does not chip, and it will require a tremendous expenditure of patience and perseverance. Glass screens of excellent quality may now be obtained commercially.

For reproduction of the very highest quality, a drawn and etched screen plate is more suitable than one merely ruled on pigment, which never gives such sharp results.

From various firms etched screen plates may now be obtained either as single or crossed-line screens, which fulfil all requirements.

The best screen to use is one with five or six opaque and transparent lines to the millimetre, which corresponds with 2,500 to 3,600 points to the square centimetre. The above number of lines will suffice for nearly all work, and such screens give reproductions in which the grain is no longer visible to the naked eye, but appears as a closed tone. It is not advisable to go beyond this number of lines, except in special cases, when the details of the drawing in the original are specially small. With a smaller number of about three or four lines to the millimetre, too coarse a grain results, of which the individual points become too plainly visible, and these are distracting and act roughly, and do not accurately reproduce the gradation of tone.

The best proportion between opacity and transparency is 1 : 1. From this is obtained, according to my opinion, the most beautiful and restful tones. It must also be remembered that the opaque spots actually lose considerably in strength in the brighter portions of the picture by the spreading action of the light.

The printing may be done on bichromated gelatine paper, with which, however, extremely accurate inking up of the print is essential, and the prints must not have too much ink and must be very carefully printed. If, however, very good, clear negatives are used, either of the direct printing methods, as already described in Chapter IV., is to be preferred. (See No. 4 Supplement.)

2. Photo-lithographic Processes in which the Grain is not Formed During the Exposure.

Of the many existing processes by which the breaking-up of the half-tones into printable lines or grain is effected, not in the negative, but subsequently by mechanical and chemical action on the stone or plate or the transfer film, I will only mention those

which appear to me to be the most important, the new methods which have already found firm footing in practical work or which appear likely to do so. All the older processes, which were either never actually successful or have been superseded on account of difficulty of working, we may properly pass over.

(A.) The Patent Asphalt Process of Orell, Füssli, and Co. used for the Preparation of Colour Prints.

I have already mentioned that the use of light sensitive asphalt for the preparation of printing plates for the various branches is by no means new.

The fundamental principles of the well-known processes we find also used in the process of Orell, Füssli, and Co.

The grained stone is coated with a thin film of light-sensitive asphalt, the composition of which we have previously learnt, and exposed under a reversed or stripped negative. The image after correct exposure is developed, and then, according to the construction of the asphalt, in combination with the graining of the stone and the developer, there is formed a finer or coarser grain, or a closed or open image.

The development is effected with petroleum, to which one-fifth or one-sixth of its volume of benzine is added, or with turpentine alone. Development takes place rather rapidly, and after a short time the image appears on the stone. The print is then treated as was suggested in asphalt printing; the stone is first gummed, and then by rolling up with ink and etching rendered suitable for printing. The pictures produced by this have a very fine grain and are in appearance very much like good collotypes; still two or more tones are necessary to obtain an absolutely closed and vigorous action.

Very similar to Orel and Füssli's process is the following, also patented.

(B.) The Colour Printing Process of Wezel and Naumann of Reudnitz, Leipzig.

In this process also all the colour stones of a chromo picture are produced from a single stripped and reversed negative which is taken of the original. For the preparation of any colour stone there are three distinct stages. The first stage is the exposure, the second the development, and the third the development continued still further, and any necessary small help by the lithographer. In each stage a special mode of treatment is required, according to whether the stone in question is to be used for a light, a more vigorous, or full colour. The stones for grey and the light blue or light red inks—thus those for many surfaces, but with few details—are treated differently to those for yellow, the second red

or blue; and these, again, differently to those for brown or quite dark colours.

Everyone only slightly conversant with colour printing knows that the first plates are used for the general tones of the picture, and contain, therefore, few details, and with the exception of the highest lights are tolerably full; the latter plates, on the other hand, which are devoted to the darker colours, contain less toned surfaces, but, on the contrary, more details of the drawings. In order to attain this correctly the three stages of the production of the plates are carried out with this end in view.

It should still be mentioned that the more or less fine graining of the stone determines the general ratio of the grain of the picture.

The first stage is the exposure of grained stone coated with asphalt. With longer or shorter exposure it is possible to make the asphalt film more or less soluble, that is to say, to make the same more or less capable of resisting ethereal oils.

It is therefore possible at this stage, by long exposure of the asphalt film, to give to the colour stone for bright colours more tone and less details. The stones for the darker inks are printed for a shorter time, and the asphalt film is less capable of withstanding the solvents, and the resulting plate contains less tones and more details. Finally, the plates for the deep colours are normally printed; the asphalt film is still less resistant, and consequently the stone will only have tone and details on those places which in printing ought to be the darkest.

It is possible, therefore, by correct manipulation of this operation, to obtain approximately the correct colour plate.

There is, however, in the second process a corrector for the first. The development may be so performed that by the longer or shorter use of strong solvents, Hungarian or Russian turpentine, more or less of the asphalt will be dissolved. Thus if a slight error is made in printing it can be made good in developing. As a rule, the stones for bright colours, which consist of many tones, are not developed so long as those for the stronger colours. The actual stones for the deep colours are very strongly developed, so that almost all the delicate parts of the picture disappear, and only the dense strong parts remain on the stone.

Still the fine details which are to be found in the vigorous parts, and which cannot be recognized, must be brought out. The fine parts of the drawing must be quite clear if the details are to be recognized, or the picture will be a fuzzy copy of the original, wanting in structure.

This fault is remedied in the third stage of the treatment, in which a strong development of the picture is effected with strong acting oils or benzole and turpentine. As this operation, however, would also wash away such delicate places which ought to remain on the colour stone, they must be covered with solution of gum and allowed to dry. Then those parts not covered with gum,

in which the details of the image cannot be seen, are painted for a longer or shorter time, as may be required, with a brush dipped in the developing solution, and when correctly developed may be covered up. The lighter places are treated for a shorter time, the very dark places for a longer time.

By this treatment the particular parts of the picture become lighter and lighter, the details appear more and more; and, finally, the whole picture shows as it should do. Then the gum is washed off and the stone subjected to the already described treatment, so as to make it suitable for printing in quantities. Finally, the lithographer can make corrections with a needle or tusch.

This process may be used, therefore, to prepare colour-printing plates from a negative obtained in the camera from an oil painting or any coloured original.

The negative for this process must contain all the details very clear, must be soft, and not be too dense.

The different colour plates are thus in this process obtained by long or short printing, by strong or weak developing, and finally the details in the dark plates are obtained by separate development and covering up the other places with gum.

The breaking up of the half-tones into printable grain is effected by graining the stone, before coating with the light sensitive asphalt film. On the finer or coarser graining of the stone depends also the structure of the grain of the image.

This process yields the most beautiful results with correct manipulation, and in the hands of an expert photographer and lithographer is a valuable aid to the preparation of colour plates. The process is patented.

(c.) J. BARTOS' PROCESS FOR PREPARING PHOTO-LITHOGRAPHS AND PHOTOTYPES IN GRAIN AND HALF-TONE.

Bartos' process belongs to those in which the breaking up of the half-tones into a printable grain is effected subsequently on the plate or stone by mechanical means. This is attained in a very original manner by means of a sandblast, which makes the half-tone printable. We have here not the breaking up of the half-tones in a mathematically regular manner, dependent on optical laws, as is the case with autotypy, but a method similar to that of Pretsch, which obtains the printable grain by reticulation of the chromated gelatine film, or other discoverers who attain the same result by asphalt dusting or some other means.

For this process a well-polished litho stone or zinc plate is coated with a thin film of varnish, composed of—

Chloroform	300 g.
Mastic	5 „
Asphalt	10 „
Benzole	300 „
Linseed oil	2 „

On the stone or plate thus prepared is transferred a carbon image in half-tone.

This pigment film, when completely dry, is flowed over with a mixture of—

Glycerine	... ...	35 g.
Water	... ...	25 „
Alum	... ...	2 „

and this should be allowed to act for about five minutes and then removed with blotting-paper. After this operation the pigment image can be easily destroyed. The pigment image is now exposed to the action of a weak sandblast. The sand acts on the relief image and gradually destroys it, and so that the film of varnish underneath is gradually grained.

After the pigment film has been removed the picture shows in all its details in grain on the varnish of the stone or plate. The image is now visible on the film of varnish, according to the strength of the tones in partial graining, and can be etched into the stone or plate.

This is effected by etching with phosphoric acid—

Water	... ...	100 g.
Phosphoric acid	... ...	4 „

When the etching solution has acted for about two minutes, the stone is washed and coated with a solution of gum—

Water	... ...	100 g.
Gum arabic	... ...	5 „

and allowed to dry.

Then the film of varnish is removed with a pad of cotton wool damped with turpentine, the dry stone rolled up with litho ink, damped, and the excess of ink rolled off. The picture now shows with all its finest details on the stone, and can be printed.

In preparing a relief printing plate the film of varnish forms the resist for the first etching. It is then rolled up and etched in the usual way.

For preparing larger pictures on stone or metal plates, in which the grain must be coarser than with small pictures, the fully-developed and still damp pigment image is dusted with powdered resin and the film allowed to dry with the powder adhering to it. The pigment image thus dusted is treated, as previously described, with alum and glycerine, exposed to the action of the sandblast, and then etched with phosphoric or nitric acid.

As the soft pigment film receives a grain by the dusting, this is reproduced of the same size by the action of the sandblast on the film of varnish on the stone or plate.

The principal points of this process of preparing photo-lithographs or phototypes in half-tone, with a grain, are as follows:—

1. From the photographic negative a pigment image is taken

and transferred to a litho stone or zinc plate, which has been previously coated with varnish.

2. The pigment image is then exposed to the action of the sandblast; and

3. Then the pigment image is removed, and the image obtained on the film of varnish is etched.

In the K.K. Hof und Staatsdruckerei photo-lithographs as well as phototypes have been prepared with excellent results by this process. The former in result are similar to the productions of the Orell and Füssli process, and the latter were noticeable for good gradation. On the other hand, it cannot be denied that this process, which is patented, has been already surpassed by autotypy, which is far simpler and easier to work, and is founded on a scientific basis.

(D.) Litho-heliogravure.

This process, invented by Chas. Eckstein, of Hague, the general director of the Topographical Bureau of the Royal Netherland General Staff, also belongs to those processes of photo-lithography by means of which any picture in half-tone can be reproduced. The breaking up of the half-tones is effected, as with the autotypic methods, by the use of a lineature, but instead of this being done in the photographic exposure, it is effected direct on the stone before the transfer of the photographic image. In this particular process the stone itself is not coated with a light sensitive film and printed on direct, but the ruling is made on the stone, and then a negative pigment image—a diapositive—is transferred to it exactly the same as with photogravure on copper. A further feature is that the result is not an ordinary transfer stone result, but an intaglio etched stone, which is printed from the depressions.

For this original process the basis is a ruled pattern stone, prepared with great care and accuracy. For preparing this a grey stone of the best quality should be taken, and one without any chalky spots, crystals, or holes. This should be polished with a coarse cloth and oxalic acid solution till it has a very high polish. On the highly-polished stone surface is spread a very thin but even film of asphalt.

The solution is composed of—

Asphalt...	...	...	...	...	5 parts.
White wax	...	...	...	...	6 „
Stearic acid	...	...	...	...	6 „

This mixture is boiled, and to it whilst boiling is added in drops a solution of two parts of soda. When cold this mixture, which is fairly hard, is dissolved in about an equal volume of turpentine, filtered and kept in bottles for use.

A sufficient quantity of this asphalt solution, which must not be sensitive to light, is poured into the middle of a levelled stone and

distributed by means of a lithographic ink roller, which must not be used for any other purpose but this, till the coating is absolutely even and shows a light brown colour.

When this film has become quite hard, fine parallel lines are drawn over the whole surface of the stone with a very accurate working ruling machine, by means of which from five to ten lines per millimetre can be ruled.

When the ruling is finished the stone is given a margin of wax, and quickly and evenly flooded with the following etching fluid—

Pure nitric acid	0·16 parts.
Alcohol 36 per cent.	0·60 „
Water	35 „

And, watch in hand, is etched for about half-a-minute.

Instead of the above a solution of—

Glacial acetic acid	2 g.
Water	100 „

may be used and allowed to act for half-a-minute. The stone is then well washed under a strong stream of water, allowed to dry, and covered with linseed oil. After about five minutes the whole of the stone may be washed with turpentine. Then it should be inked up with a pad, care being taken that all lines take the ink well and evenly. This pattern stone serves as the original plate for the subsequent ruled transfer.

From the original ruled stone can be made, according to the nature of the original, a single, double, triple, or four-fold transfer.

For preparing a stone with a ruled transfer, a smoothly ground stone well polished with oxalic acid is evenly coated with sensitive asphalt solution. On this, when dry, the desired single or crossed transfer from the original stone is made, and dusted with bronze powder. This adheres to the lines of the pattern, and in combination with the printing ink protects the asphalt film underneath from the action of light. During the subsequent exposure, which, according to the sensitiveness of the asphalt and intensity of the light, can last from a half to two hours or more, the particles of asphalt not covered by the bronze powder become insoluble, whilst the protected parts preserve their solubility.

After correct exposure the surface of the stone is carefully washed with a tuft of cotton wool soaked in oil of turpentine, when the particles of asphalt underlying the bronzed lines dissolve. The stone at these parts is laid quite bare, and therefore made capable of being subsequently etched. The deep etching of the pattern is effected in the same way as was suggested in the preparation of the mother pattern stone.

By this method a positive pattern is obtained, that is to say, the lines print, and the impression shows therefore a black network.

A second method of making a pattern transfer consists in making a pull from the original stone on to chalk transfer paper.

This pull is then damped on the back, and when just properly damp is laid on the polished stone (without any asphalt) and the transfer made. In order to remove the chalk paper without damaging the pattern the stone is covered with warm water, when the lines will dissolve. The simple pattern will now be found on the stone, which should now be well washed, then dusted with resin powder, which should be melted on with ether vapour. Then if the direction of the first lines was vertical, the second transfer is arranged with the direction of the lines horizontal to the first, and there is thus obtained a simple crossed pattern. With four-fold crossed patterns the subsequent pulls are made in opposite diagonal directions. After each transfer the stone is well washed, allowed to dry, then dusted with resin powder, and with ether melted on to the pattern.

The stone is now deep etched with dilute nitric or acetic acid and covered with linseed oil.

By this method a grain instead of lines is obtained. By polishing the stone and transfering on to it, as well as by etching the places not covered by the ink, we have the pattern reversed, that is to say, it is converted into grain.

For further operations of litho-heliogravure a very clear and soft negative is required, from which a glass transparency is taken. Under this transparency pigment paper sensitized on a 20 per cent. solution of potassium bichromate is printed to 8 or 10 degrees Vogel. Printing must be very carefully performed, as with under-printing too many details are lost. The exposed pigmented paper is washed in cold water, laid film side down on the previously prepared stone, and pressed into contact with an india-rubber squeegee. It should then be allowed to dry in a not too dry or too warm place.

The stone should now be placed in a trough with warm water of about 40 to 45° C., and care should be taken to obtain water of as even a temperature as possible. After about five minutes the paper will be free from the stone, which should remain in the bath and be developed so long by shaking in order that the water may flow evenly over it till the image appears quite distinct ; a negative image is thus obtained on the stone. The film is then allowed to dry spontaneously for four or five hours till the pigment image has become quite hard.

For etching a solution of perchloride of iron of various strengths is used, 40, 37, 33, and 30° Beaumé. With subjects very rich in tones all four will be used ; with simpler subjects one or the other may be omitted.

The etching will begin, as a rule, with the 40° solution. The ferric chloride will first dissolve the thin, hardened pigment film and then go through the open lines of the pattern, where it will attack the stone and etch the deepest parts.

Slowly the ferric chloride dissolves also the thicker pigment

film—begins also to etch the stone there, but less deeply. To tell when the four solutions should be used in turn, as well as the correct moment to interrupt the etching, requires considerable experience. The 30° solution, the weakest of the ferric chloride solutions, is used last, and in consequence of the greater proportion of water possesses a solvent power for the whole of the light-hardened pigment film. Accurate directions as to how long the etching with the different solutions is to be continued cannot be given, as this depends upon the character of the subject as well as upon the thickness of the pigment image. It may be always assumed, however, that any individual etching ought to last under no circumstances longer than three to four minutes. With well-covered stones the first etching should not be allowed to act so long as the last, and *vice-versâ* with less covered stones.

As soon as the image shows the correct character through the etching solution the stone should be brought under the tap in the trough and quickly washed with clean cold water. The surface of the image should then be flowed over with oil of turpentine in order to remove the asphalt and gelatine film, and finally well washed with the rose and allowed to dry. The picture will be found deeply etched into the stone. The stone is now smeared over with linseed oil, inked up, and further treated as in ordinary lithogravure.

In this process the negative pigment image is transferred to the stone and the printing image prepared by etching; the formation of the grain is produced by the pattern printed either on a polished stone, when it is converted into points, or the transfer may be effected on to an asphalted polished stone, when a network of lines will be obtained.

For dark subjects the latter process is better, for lighter subjects the grain.

Printing from such a plate has more similarities with etching printing than from stone; the effect of the ink is very good and expressive.

Various pictures executed by Eckstein and in our establishment in one or more colours have proved the value of this process in practice.

The foregoing are the different photo-lithographic methods for obtaining printing images in half-tone, and although in no way exhaustive, yet it appears to me that they are practically the most important.

APPENDIX.

1. Negative Transfer with Bichromated Gelatine Paper.

The properties of bichromated gelatine paper can also be very well used for the so-called negative printing, and this method offers many advantages.

In order to convert a positive printing image into a negative various methods may be used; the most convenient for the lithographer is the following:—A good litho stone is first ground in the ordinary way and then the surface rubbed with a pad and oxalic acid solution till it has a high glaze or polish. On to this stone is then transferred a sharp impression in a non-greasy ink from the positive printing image. According to the destination of the stone for large or small editions one of two processes may be adopted. If a thousand or more pulls are required from the stone the transfer may be dusted with resin powder, and this melted with the burning, heating, or ether process and the drawing etched in relief with 8 to 12° nitric acid and gum. Then the stone may be well washed with water and the acid removed with one to two per cent. acetic acid.

For small runs the first etching is omitted, and the stone treated with acetic acid. In both cases the stone should be well washed, dried, and then coated with dissolved lithographic tusch or autographic ink. The greasy substances of these materials penetrate into the surfaces of the stone that are laid bare, and firmly adhere. When the tusch or ink is completely dry the stone is washed with turpentine, inked up, and one now has a negative image from the subject in question, which shows all the original printing places in white and all white places black.

The process of preparing such negative prints by the use of bichromated gelatine papers is much simpler.

A sheet of gelatinized paper is sensitized for this purpose on a 5 per cent. bath of potassium bichromate, squeegeed to a sheet of plate-glass and well dried, and on this is made with black ink, which is very opaque, in the dark or in gaslight, a sharp clean print. This print is then laid on a flat table, under a sheet of plate-glass, so that it cannot roll up, and exposed to the light for from five to thirty minutes. A long exposure rarely does harm in such cases, as the good opaque black ink allows no rays of light to pass through to those places which later should print white.

The next manipulation is the development and inking up, which is done as in ordinary photo-lithography. In this operation all

those places which were not covered up by the printing will take the developing ink; on the other hand, those places where the impression was will wash out clean and white. The print has assumed the appearance of a photographic positive. The print is now treated like any other photo-lithographic print, and finally transferred to a stone or zinc plate. This method is distinguished by its simplicity and safety; it has also the advantage that any desired printing subject can be directly transferred in negative form to a zinc plate for relief etching, which otherwise could only be done by preliminary transfer to stone and subsequent transfer to zinc.

2. Photo-autography.

DRAWING WITH AUTOGRAPHIC INK OR LITHOGRAPHIC CHALK ON A CYANOTYPE, SALTED OR OTHER PRINT FROM A PHOTOGRAPHIC NEGATIVE OR POSITIVE.

By autography we understand that method of reproduction by which any writing or drawing is made on a prepared or not prepared paper with greasy ink, tusch or chalk, which is subsequently transferred to stone or zinc for printing, or to zinc plates for relief etching.

Autographic drawing papers differ for the different purposes, and for writing and simple line drawings smooth hard post paper is used, and lined transfer paper for fine pen or chalk drawings. The latter are prepared commercially by Angerer and Göschl. Very beautiful grained drawings can also be made for transfer on pyramidal grain paper. The proof for such drawings is usually done with lead pencil or red chalk, or it may also be made on a gelatine proof.

In order to obtain fully and completely the character and correct reproduction of the drawing, without special expense of artistic help, it is advisable to use a photographic print as proof. It should be noted that for pen drawing on smooth paper with greasy tusch or ink, for chalk drawings on a prepared grained paper done as previously mentioned, with greasy lithographic chalk, the drawing should be transferred direct to zinc or stone in order to save having to make subsequently a photographic print.

If a pencil, red crayon, or other proof is used for an autographic drawing on paper with the idea of transferring it direct to stone or zinc, a suitable photographic print may also be used on suitable paper without any disadvantages.

For the prints all photographic papers without glaze, such as ordinary plain salted paper, Eastman's positive bromide paper, and others, may generally be used. Glossy or albumenized papers are not suitable for this, as the ink runs, and does not form solid clean lines.

The best of all, however, is cyanotype paper, as even with very deep printing it keeps the details in the shadows open, and on account of its blue tones is more suitable for the subsequent drawing with black tusch. When, however, prussiate paper is not handy, and subjects with fewer shadows and less details are to be treated, any of the other papers above-mentioned may be used.

If ferro-prussiate paper is to be used, the same may be prepared as recommended on p. 23.

The so-called salted or plain paper is prepared as follows:— A sheet of well-sized post paper is first bathed in a solution of —

Ordinary salt	1 part
Water	25 parts

and then sensitized in a solution of silver nitrate 1 : 12. It is printed till the print has assumed a fairly full brown tone, and all the details in the shadows are well printed out. It should then be toned in the following toning bath:—

Distilled water	1000 g.
Sodium acetate (twice fused) ...	15 ,,
Solution of gold chloride (1 : 100)...	25 ,,

till the print has assumed a deep dark brown tone. It should then be fixed in a solution of sodium hyposulphite, 1 : 15. It should be printed rather deep, as in toning and fixing the image loses in depth. It is moreover unnecessary in this case to make a beautiful print; the chief thing is only that all details of the image should be clearly seen. The print is then well washed in frequent changes of water and then dried.

The print on Eastman's bromide paper is prepared as follows:—

Red light must be used. It should be printed by an ordinary gas flame at a distance of about 50-80 cm. (=24 to 36 ins.) for 1 to 20 seconds, according to the density of the negative. Here again a technically perfect print need not be arrived at, but one which contains all the details very clear. Under a good transparent negative a useful image for the artist will be obtained with about two seconds' exposure.

The developer is composed of two solutions :—

(A.)	Water	500 g.
	Neutral oxalate of potash	165 ,,
(B.)	Water	50 cm.
	Sulphate of iron	15 ,,
	Concentrated sulphuric acid	2 drops
	Or glacial acetic acid	5 ,,

Three parts of solution A and one part of solution B should be

mixed together. As soon as the shadows have attained the desired tone, the prints should be placed in several fresh baths of

Water	200 ccm.
Acetic acid	1 drachm.
Sat. sol. alum...	50 g.

and then washed and fixed in a bath of

Water	50 ccm.
Sodium hyposulphite...	10 g.

for about ten minutes. Then well washed and dried.

For pen drawings all not gelatinized or albumenized printing papers may be used as already mentioned. The chief thing is that the paper should be well-sized and of good firm texture. If prepared grain paper is used, which is provided with a film of chalk, kaolin, or any other white colouring matter combined with gelatine, and on which film the grain is impressed, only prussiate prints can be used. The paper is sensitized as previously described, only it is advisable not to leave it too long in the solutions, or else the film may become softened. The film will also dissolve in hot water at about 80° C.

The prints as soon as dry can be used for drawing on. On the grain papers the outline may be drawn with the pen and be shaded with chalk, or it may be drawn with chalk only. With unprepared papers it is advisable to coat them with a thin solution of boiled starch, as then the transfer to zinc or stone is most exact. The drawing may also be left a long time without spoiling. The coating is performed with a pad dipped into the liquid, which consists of one part of fine bookbinder's starch and four or five parts of water, and passed several times over the print.

The drawings ought only to be done with greasy lithographic tusch or chalk or autographic ink, which consists principally of greasy materials and lampblack. For pen drawings hard pens should be used, and care must be taken to make thick strokes. Only a little tusch or ink ought to be taken into the pen, so that it does not run out, and thus clean, sharp lines be obtained. If this be observed very close shadings and cross lines can be produced clean and neat.

When the drawing is finished and the tusch or ink has become dry the same should be laid between damp blotting-paper, and meanwhile a clean ground, and dry pumiced stone worked in the press and the pressure correctly adjusted. As soon as the drawing has become moderately damp right through, and the paper feels soft without being wet, it should be laid with the image downwards on the stone and transferred to the same with strong pressure. After repeated working the paper will adhere firmly to the stone. In order to loosen it the stone should be covered with hot water of about 80° C., when the film will dissolve and the paper become quite free. Any exertion of force must in this

operation be quite avoided, and the paper must not be pulled off with violence. All, even the finest lines, will have been transferred to the stone. The stone is now gummed, if possible allowed to stand for some hours, and then etched with a gum etching solution of two degrees' acid strength, or later etched in relief, and is ready for printing. If the transfer is made to zinc, for printing from this the plate is treated as suggested on p. 6. If, however, a relief etching for the typographic press is to be prepared of the subject, the transfer is made on to a smooth polished zinc plate.

3. Lithogravure.

With this particular process an intaglio printing stone or intaglio printing plate is prepared by chemico-physical means.

This process was discovered and brought to great perfection by Chas. Eckstein, the general director of the Typographical Bureau at the Hague, and offers especially many advantages for the reproduction of maps.

A map engraved, drawn, or transferred on stone, or written in on copper, in originally one colour, can by this process in a comparatively easy way be converted into a many-coloured print; this process can also be used very advantageously for changing the names for the places—rivers, mountains, etc. In the first place intaglio original printing plates in all the colours can be prepared which can then be printed for further reproduction; in the second case it is necessary to re-engrave the network, hydrography, etc.,

When it is desired to convert a monochrome image into a multi-coloured map, as many stones as there are colours to be used must be first ground and polished with oxalic acid till they have a high polish.

In the meantime an asphalt or other light-sensitive solution should be prepared, with which the stone is coated in the dark very evenly, and somewhat more than is done for a photo-lithographic print.

The asphalt solution is composed of —

Syrian asphalt	...	...	...	20 g.
Chloroform	...	...	...	300 g.
Benzole	...	...	...	100 g.
Oil of lavender	...	...	...	20 drops.

After it has been dried in the dark the impression from the black plate, which should be previously made on transfer paper, is transferred to the asphalt film as previously laid down, and before it is dry dusted with bronze powder. All lines, titles, or figures which should not appear on that particular colour-plate must be then covered with the above asphalt solution, and only those places, for example, on the one plate all titles, on another all the roads, on a third the river courses, and so on, should be left, all of which later should appear in printing.

The stone is now, according to the sensitiveness of the film and the strength of the light, exposed for from fifteen minutes to two hours. Over-printing, if it is not very exorbitant, does not do any harm with the stronger letters or lines on account of the good covering. With very fine lines, however, more care must be taken. If there is any doubt as to the length of the exposure a test may be made at one corner of the plate with a pad dipped in rectified turpentine. When the asphalt will no longer dissolve the exposure may be discontinued. With some experience the photometer may also be used.

Then the whole surface should be washed with rectified turpentine and a pad of cotton wool, when the ink lying under the bronze, that is, the lines where the asphalt has been protected from the action of light dissolve, and the surface of the stone appears. The rest of the asphalt film has become insoluble from the action of light, and now forms the etching-ground for the reversed negative image on the surface of the stone.

When the stone has been well washed with water it may be etched, which is done with glacial acetic acid two parts, water 100. When there are any fine lines in the drawing the etching is interrupted at the end of two minutes, and they should then be covered with tusch, and then when the tusch is dry the other parts are further etched for a longer or shorter time according to the degree of fineness. In any case the time of etching should not exceed five minutes. The stone is allowed to dry and then coated with a solution of tusch or linseed oil, which penetrates into the etched parts and makes them capable of taking ink. After about ten minutes the whole stone should be washed with turpentine or benzole, by which the etching ground is removed, when the stone is inked up like an ordinary gravure.

In this way is obtained a stone with deep etched drawing, which according to the blocking contains the titles, the rivers or roadways, and from which subsequently the necessary gravures can be taken. This stone can either be used for direct printing or it may be used as an original stone from which the necessary transfer can be made.

The same process may also be made for intaglio printing plates on zinc or copper, only then the etching must be done with nitric acid or ferric chloride.

Instead of the transfer on the light sensitive film, a drawing on transparent paper may be used, or a photographic transparency. The exposure in this case, as the opaque ink and bronze powder are not used, must be very carefully estimated.

The advantage of this process is that an intaglio printing surface may be obtained so that engraving is entirely or partially avoided, and that this printing surface may be used as an original from which the reproductions are made.

Scraper Boards, Manufactured by Augerer & Göschl, Vienna.

No. 6.—A white scraper board printed with black lines. There are 40 black and 40 white lines to the centimetre; the ratio of black to white is as 1 : 2. At right angles to the black lines impressed lines are arranged, of which 37 are depressed and 37 raised up to the square centimetre.

No. 7.—This is practically the same as No. 6, only that the lines are slightly less in number, namely, 35 black and 35 white and 26 impressed lines in equal areas to No. 6.

No. 8.—This contains dots instead of lines, both black and impressed; there are 1,156 black dots at regular intervals, and 961 impressed dots to the square centimetre.

No. 9 is a smooth scraper board.

Nos. 10 and 11.—These are impressed with straight lines in the proportion of 1 : 1. With No. 10 there are 27 lines, in No. 11 37 lines to the centimetre.

Nos. 12 and 13.—These are impressed with lines at right angles to one another, so that regular squares are formed. No. 11 contains 730, No. 12, 1,370 squares in every square centimetre.

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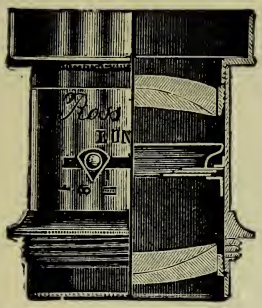

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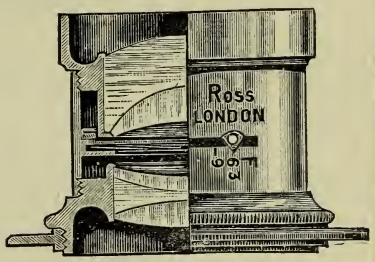

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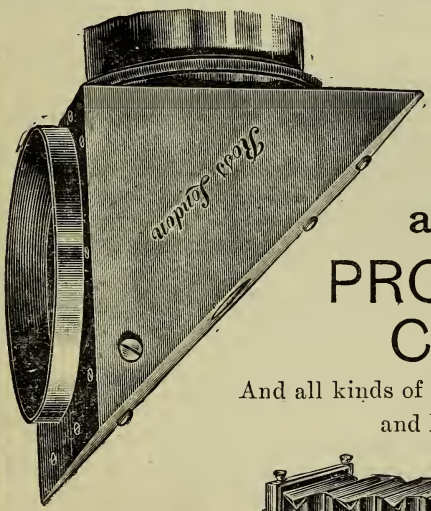

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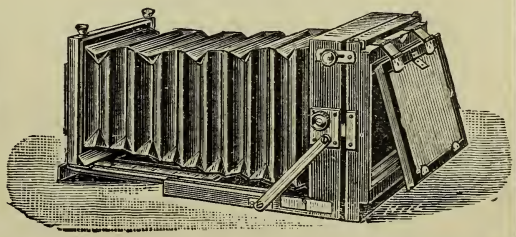

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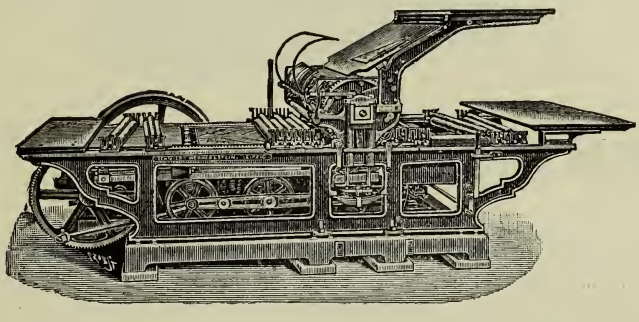

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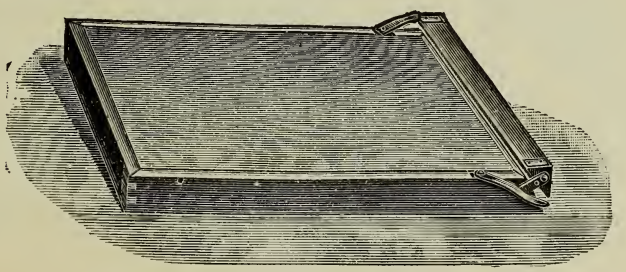

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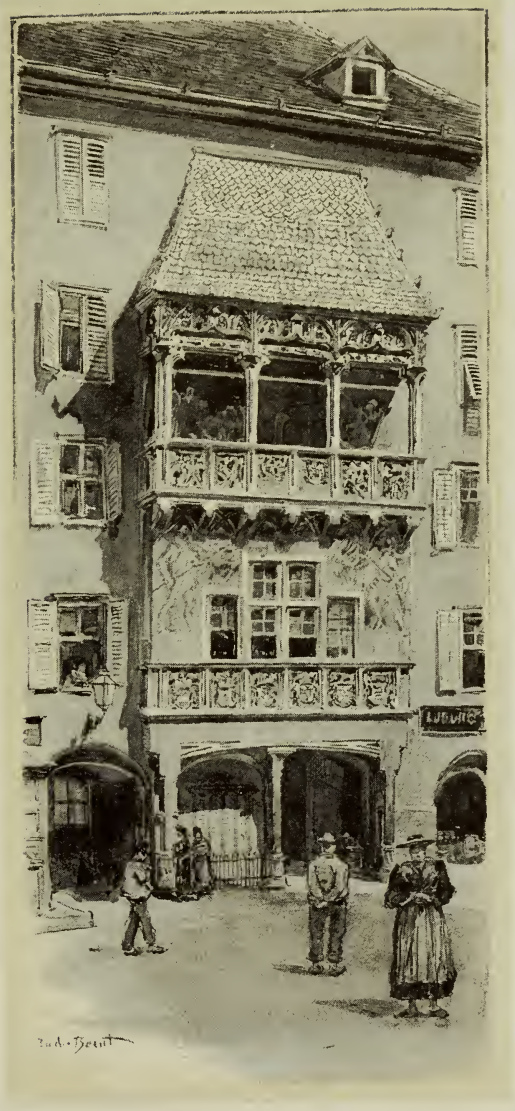

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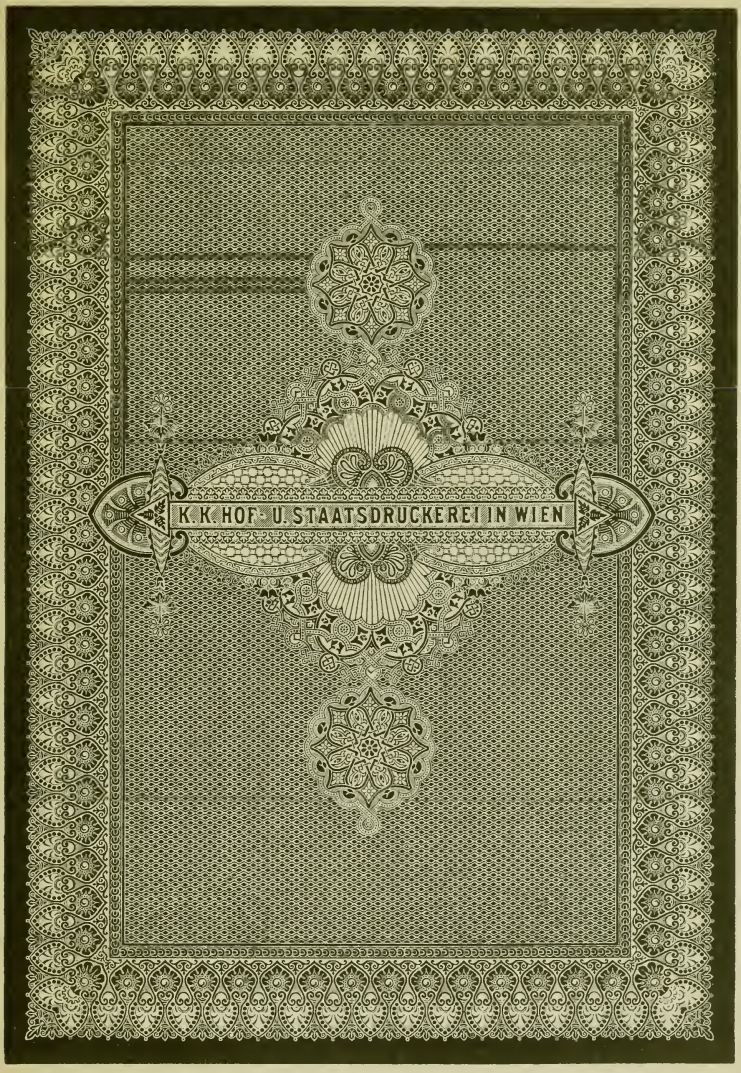

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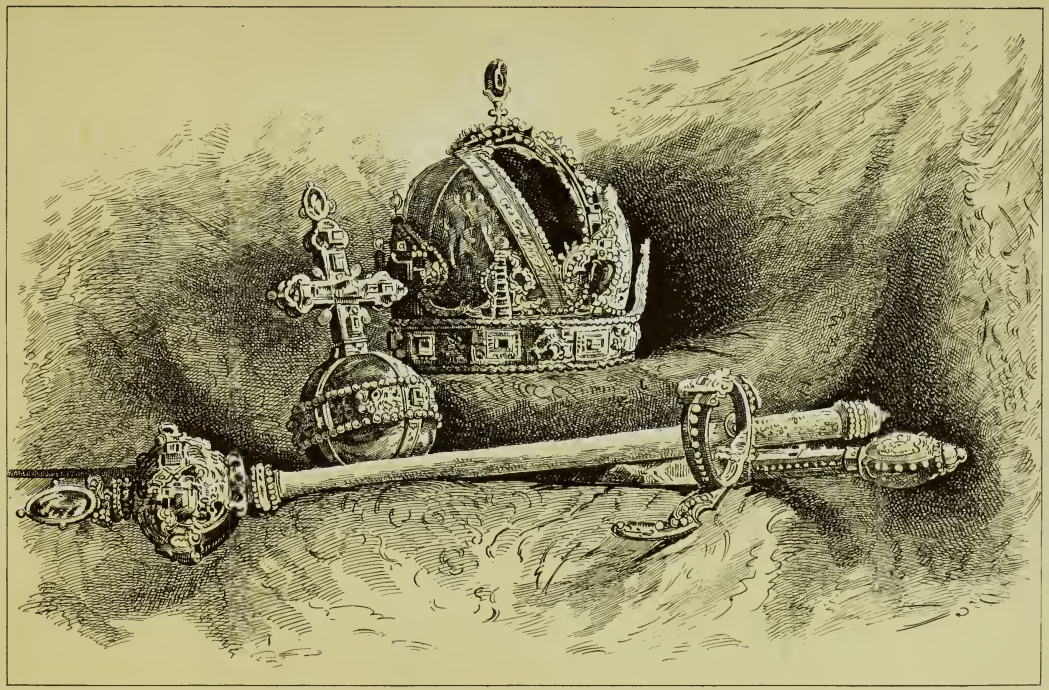

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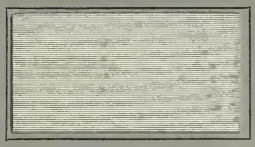

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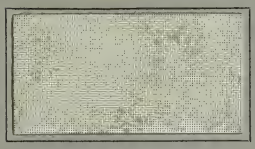

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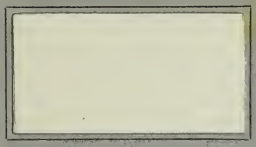

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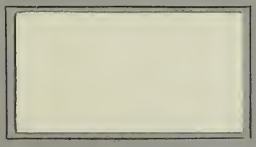

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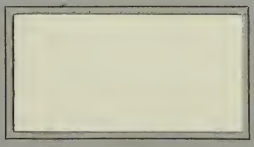

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